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Diverting Attention to the Classroom

By J. R. KILLIAN, JR.

Vice President for Engineering College Administrative Council, A.S.E.E.

During the war we had "crash" research projects which were so named because all barriers were broken down to bull the projects through to completion.

In the overload of students assumed this fall, our colleges have a crash program which demands a comparable singleness of purpose and an equally relentless disregard of difficulties. If anything, the difficulties faced are greater. Money, men, and materials are far harder to come by. Moreover, as more than one college administrator has ruefully pointed out, getting the job done is requiring an extraordinary preoccupation with such nonacademic matters as bedding and sewer pipe and the abstruse formula for computing rentals on F.P.H.A. housing. The chief energies of administration and faculty have seemingly been channeled into the Buildings and Grounds Department.

This attention to the hard, elementary facts of food and shelter, however demanding, is the least important part of the program; that the real crash program remains in the classroom and the laboratory is a truism that needs to be emphasized in the face of such distractions as dramatic housing projects and the accounting perplexities of the Veterans Administration.

After the First World War, with fewer difficulties and distractions to face, all too many engineering colleges allowed standards to drop. Degrees were watered down; men were graduated with an imprimatur they subsequently failed to justify. This should not be permitted to happen again. Present conditions, on the contrary, call for higher professional standards and the most effective teaching we can muster. Veteran students, with the maturity and ability they clearly possess and with the vocal and organized way they express their wishes, not only deserve but will vociferously demand educational efficiency.

With admirable foresight, this society sponsored more than three years ago the study and report on "Engineering Education After the War." In supplement to this, it now has under consideration a report on "Academic Tenure, Professional Service and Responsibility," which examines another facet of educational policy in terms of postwar conditions. The long view and the preoccupation with educational philosophy, attitude, and method emphasized in these reports and in many other activities of the society must, as they surely will, supersede the currently inescapable concentration on housekeeping.

More than ever before we need to be alert to strengthen our work in the classroom, to make sure that the large number of new and inexperienced instructors are aided to develop teaching

proficiency. This will require exceptional efforts. The increasing requests for teacher training programs, the wide interest in such excellent manuals as Virginia Polytechnic Institute's "Effective Teaching," and the nation-wide re-examination of educational objectives are indications of the returning ascendancy of the classroom in our educational institutions.

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Post-War Mineral Engineering Curricula*

By J. D. FORRESTER

Professor of Mining Engineering, Missouri School of Mines and Metallurgy

In a logical analysis of Post-War Mineral Engineering Curricula we should first examine our desires and purposes in engineering education and on such bases found our determinations and conclusions. What are these guiding controls in Mineral Engineering Education? Fundamentally they are: 1. To train men in the technology of engineering so that they are qualifted to act in their fullest professional capacity in industry. That is, so bend or direct scholastic enterprise that the young man, as an educational product, is prepared to assume a full, balanced professional role by applying engineering principles in the discovery, extraction, beneficiation, smelting and refining of ores and other minerals and rocks from the earth. 2. To prepare and imbue our graduates with such a cultural and ethical consciousness as to make them better present and future citizens of our Country and of the World. These two purposes are not so diverse and widely separated as many of us would suppose. Certainly, for example, an engineer is trained in logic, legitimate progression or forebearance, and in honesty—if these characteristics can be distinguished and differentiated. Certainly, also, these are the characteristics which must be practiced in private and public life if the Nation and the World are to experience the growth and development everyone should desire. The proposition may arise that this all seems very good; but here we have a concrete question before us and what are we going to do about it?

With these above controlling desires and purposes before us, and with which, it is believed, we are all in essential accord, the writer's opinions are as follow:

1. Short (vocate) courses of study as offered by some mineral engineering schools should be discontinued. They are of technician caliber and not of engineering grade. Further, they do not give the rounded training we are seeking to accomplish and they simply consume the time of an instructing staff which could otherwise be devoted to engineering teaching and research.

2. Some phases of mineral engineering education have stagnated. This, among other tendencies, has had the effect of discouraging students of outstanding ability to enroll in our profession and likewise, has been a major contributing cause for the lack of interest many employers have taken in our schools and their products. We have failed for several years to furnish them properly prepared raw material in numerous cases and, therefore, the employers often have tended to discount the technical school's contribution and have failed to advance men at

* Presented at S.P.E.E., Mineral Engineering Division, June 20, 1946, St. Louis.

reasonable rates. The welfare of young engineers in industry is not the sole responsibility of employers and to hold that industry is alone to blame for low salaries and slow advancement so generally prevalent in the minerals industry, and particularly in mining, is a serious failure on our part as teachers to grasp the full significance of the problem.

In many schools mining curricula are today as they were 25 to 30 years ago. They should be, and must be, re-examined and brought into line, on the basis of good engineering standards, with the growth and development of mining practices now in effect. Men must be trained not only in mine mechanization such as loading, hauling and hoisting but likewise in the principles of safety engineering, mine ventilation and atmospheric control. Further, we must come to realize that Mining has now become so specialized that it is no longer possible to fully train a man in all phases of mining enterprises. Exploratory, evaluating engineers working as mining geologists are specialists functioning in a distinct field of mining just as are those men concerned with mine operating and labor relations. The mining geologist must be fully trained in applied geology but he also must know general mining practice. He is a complete engineer and the writer believes the E. C. P. D. Examining Boards, in the past have made wise designations when they have seen fit to classify mining geologists under an option of the major division, Mining Engineering.

Metallurgical Engineering professional training has not stagnated to the degree that Mining has for we all generally recognize the various divisions of this branch and we have, as a result: Mineral Dressing, and Production and Process Metallurgy as distinct phases. Therefore, in view of these relations the writer suggests for our consideration the adoption and recognition of *Mining Geological Engineering* as a distinct, separate, division of Mining Engineering, as a whole.

3. Research in Mining Engineering should be and can be more extensively developed. All such work can be designed to contribute to science, to train outstanding engineers, and to offer findings of direct, practical value to industry.

4. Closer correlation between industry and education should be striven for. Two ways to accomplish these closer relations are: (*a*) Place men in teaching positions who do not have only an academic technical training but who also have served some time in practice and thus have industrial experience; (*b*) work in direct contact and co-operation on research projects with industrial organizations.

5. Logic, Ethics, and Government should not be taught fundamentally by English Departments as phases of English or American Literature courses. Such departments have a wealth of excellent subject matter with which to treat and why they so commonly persist in deviating, often on a poorly directed trend, from their outlined course of instruction is difficult for an experienced engineer to comprehend and tolerate. This is particularly pertinent when their acknowledged subject matter appears to suffer, as a result.

6. Every school regardless of its type should, as a Humanity course, require training in the Conservation and Utilization of Natural Resources. Nothing contributes to better citizenship than studies of this character. There are only two ways to preserve our resources properly. That is, either

by law or by education and, personally, the writer prefers education.

Our purpose in these symposia is to consider and integrate the principles of necessary training which our minerals engineers should have as technologists and as citizens. Both of these classifications, as has been stated, are of fundamental importance. Therefore, in summary it would appear that we must:

1. Make fully trained engineers competent to handle problems of various specialities in the minerals industry profession. We should recognize their individual status as engineers and the need for a degree of specialization. This is because present day technology is not amenable to treatment in detail by a *general* engineer.

2. Make training in the general humanities, and particularly in natural resources, a portion of all engineering curricula.

3. Analyze curricula with these above points in mind. The complexities of our civilization and the maintenance of our successful engineering development absolutely require the accomplishment of these ends. If, as many men suggest, they can be realized only by 5 year courses of study; then are we *bound* to 4 year programs simply because of what has been in effect in the past and by our fear or failure to be progressive enough to move ahead? If we need 5 years we had better come to such a plan. However, the writer believes we can develop satisfactory 4 year courses of study which as engineering specializations are ample for our purposes. In accordance with this thought specimen curricula in several branches of mineral engineering have been prepared. These are offered as at least foundations on which we can proceed to build and develop. The proposed curricula have been outlined on the basis of approximately 160 semester-credit hours of total academic work and include time allocated to military training and/or physical education. In each case, the "General Subjects" are to be considered as complementary to the program of the specific field. That is, the total credit hours of general subjects plus the total given under any particular major curriculum heading will equal approximately 160 semester-credits.

A Proposal of Mineral Engineering Curricula

Offered as a basis for further analysis of such professional training

General Subjects

Basic to All Mineral Engineering Curricula

Chemistry

General Chemistry	6
Qualitative Analysis	5
Quantitative Analysis	4
Engineering Physics	10

Mathematics

Plane and Spherical Trigonometry	5
Analytical Geometry	5
Calculus (Differential and Integral)	8

Engineering Drawing

General Engrg. Drawing	2
Descriptive Geometry	2

Surveying

Plane Surveying	3

Engineering Mechanics

Statics	3
Dynamics	2
Mechanics (Strength) of Materials	3

Geology

General Geology (Physical and Historical)	7
Mineralogy (Elementary)	5

Humanities

Literature	3

Economics; Sociology; History; etc. ... 6
Conservation and Utilization of Natural Resources ... 3
Engineering Ethics ... 3

Rhetoric and Composition ... 6

Physical Education and/or Military Training ... 6

Work in Practice .... (3 months, summer)

Senior Trip ... (During senior academic year)

MINING ENGINEERING (OPERATING)

Surveying
Advanced Surveying ... 2
Mine Surveying ... 4
Field and Mineral Land Surveying ... 3

Mining Engineering
Elements of Mining ... 4
Mine Ventilation and Atmospheric Control ... 2
Mine Safety Engineering ... 2
Prospecting and Mine Development ... 3
Mining Methods ... 3
Mine Plant ... 4
Mine and Mineral Land Evaluation 3

Mechanical Engineering
Thermodynamics ... 3
Power Plants Laboratory ... 1

Electrical Engineering
Electric Circuits and Machines ... 5

Geology
Geology of Ore Deposits ... 3
Geology of Nonmetallic Deposits ... 3
Lithology ... 2

Hydraulics ... 3

Stresses and Framed Structures ... 4

Metallurgical Engineering
Outlines of Metallurgical Practice ... 3
Mineral Dressing ... 4

Recommended Electives (optional choice)
Sociology
History
Mineral Reports and Records
Coal Mining
Advanced Safety Engineering
Surface Mining Methods
Mine Cost Accounting
Mining Law
Engineering Contracts and Specifications
Techniques of Mining Geology
Differential Equations
Foreign Language

MINING GEOLOGY
OR
MINING GEOLOGICAL ENGINEERING

Surveying
Mine Surveying ... 4
Field and Mineral Land Surveying ... 3

Mining Engineering
Elements of Mining ... 4
Prospecting and Mine Development 3
Mineral Reports and Records ... 2
Techniques of Mining Geology ... 2
Mine and Mineral Land Evaluation ... 3

Geology
Map Interpretation ... 2
Structural Geology ... 3
Stratigraphy ... 3
Paleontology ... 4
Geology of Ore Deposits ... 3
Field Geology ... 2
Geology of Nonmetallic Deposits ... 3
Petrography ... 4
Mineragraphy ... 2
Petrology ... 3

Hydraulics ... 3

Geophysics
Prin. of Geophysics ... 2
Applied Geophysics ... 2

Metallurgical Engineering
Mineral Dressing ... 4

Recommended Electives (optional choice)
Petroleum Geology
Petroleum Development and Production Methods
Sociology
History
Mining Law
Engineering Contracts and Specifications
Advanced Geophysics
Foreign Language
Outlines of Metallurgical Practice
Physical Chemistry
Thermodynamics
Advanced Physics
Electric Circuits and Machines
Introductory Ceramics

Petroleum Engineering

Surveying
- Field and Mineral Land Surveying 3

Petroleum Engineering
- Petroleum Engineering Principles 3
- Petroleum Production Methods 3
- Petroleum Production Engineering 7
- Petroleum Valuation and Economics ... 2
- Petroleum Engineering Design 3
- Natural Gas Engineering 4

Mechanical Engineering
- Power Plant Laboratory 2
- Thermodynamics 3

Geology
- Map Interpretation 2
- Micropaleontology 2
- Petroleum Geology 4
- Structural Geology 3

Hydraulics 3

Chemical Engineering
- Physical Chemistry 5
- Organic Chemistry (Aliphatic) 6

Metallurgical Engineering
- Physical Metallurgy Testing Laboratory 1

Electrical Engineering
- Electric Circuits and Machines 5

Recommended Electives (optional choice)
- Advanced Physics
- Principles of Geophysics
- Applied Geophysics
- Foreign Language
- Sociology
- History
- Advanced Mechanics of Materials
- Mechanical Vibrations
- Advanced Materials of Construction
- Principles of Metallurgy
- Differential Equations
- Machine Design
- Internal Combustion Engines
- Engineering Contracts and Specifications
- Mineral Reports and Records

Mineral Dressing (Metallurgy)

Metallurgical Engineering
- Fire Assaying 4
- Introductory Metallurgy 4
- Ore Dressing 8
- Metallurgical Calculations 6
- Mill Plant Design 4

Mechanical Engineering
- Power Plants 4
- Power Plant Laboratory 1
- Thermodynamics 3

Electrical Engineering
- Electric Circuits and Machines 5

Hydraulics 3

Geology
- Petrography 3
- Mineragraphy 3

Mining Engineering
- Elements of Mining 4

Chemical Engineering
- Physical Chemistry 6
- Chemistry of Colloids 3

Recommended Electives (optional choice)
- History
- Sociology
- Mine and Mineral Land Surveying
- Differential Equations
- Foreign Language
- Engineering Contracts and Specifications
- Advanced Physics (Light, etc.)
- Advanced Physical Chemistry
- Stresses and Framed Structures
- Mineral Reports and Records
- Metallurgy of Iron and Steel
- Metallurgy of Nonferrous Metals
- Geology of Ore Deposits
- Geology of Nonmetallic Deposits
- Advanced Quantitative Analysis
- Spectrum Analysis
- Phase Rule

Production and Process Metallurgy

Metallurgical Engineering
- Introductory Metallurgy 4
- Metallurgical Calculations 4
- Metallurgical Plant Design 4
- Metallurgy of Iron and Steel 3
- Physical Metallurgy Testing Laboratory 2
- Electro Metallurgy 3
- Ore Dressing 4
- Fire Assaying 4
- Principles of Metallurgy 3
- Metallurgy of Nonferrous Metals 3
- Alloys and Metallography 3

Mining Engineering
- Elements of Mining 4

Electrical Engineering
- Electric Circuits and Machines 5

Geology
- Mineragraphy 3

Mechanical Engineering
- Thermodynamics 3
- Power Plants 2
- Power Plant Laboratory 2

Chemical Engineering
- Physical Chemistry 5

Recommended Electives (optional choice)
- Stresses and Framed Structures
- Sociology
- History
- Foreign Language
- Differential Equations
- Phase Rule
- Spectrum Analysis
- Advanced Metallurgy
- Engineering Contracts and Specifications
- Advanced Physics
- Advanced Physical Chemistry
- Mineral Reports and Records
- Advanced Quantitative Analysis
- Geology of Ore Deposits
- Geology of Nonmetallic Deposits
- Introductory Ceramics

Some Fundamental Theorems of Structural Mechanics in Vector Notation*

By R. J. DUNHOLTER

Associate Professor of Mechanics, University of Cincinnati

The equation of virtual work, Maxwell's reciprocal law, and Castigliano's displacement theorem can all be presented for a complete structure consisting of bars subject to direct stress, bending, torsion, or shear by using the vector notation.

In general a concentrated load has six components which can be ordered as follows:

$$\mathbf{F}=[F_x, F_y, F_z, M_x, M_y, M_z]=[F_\alpha], \quad \alpha=1, 2, \cdots 6, \quad (1)$$

where F_x, F_y, F_z are the components of force and M_x, M_y, M_z are the components of moment. In general the X and Y axes are the principal axes at the centroid of the section at which the load acts and Z is the normal. Similarly there are six components of displacement:

$$\boldsymbol{\delta}=[\delta_x, \delta_y, \delta_z, \theta_x, \theta_y, \theta_z]=[\delta_\alpha], \quad \alpha=1, 2, \cdots 6, \quad (2)$$

where δ_x, δ_y, δ_z are the components of linear displacement of the centroid of the section and θ_x, θ_y, θ_z are the components of angular displacement of the section about the X, Y, Z axes respectively.

If the components of displacement δ_α are infinitesimal then the work of the load $\mathbf{F}$ over the displacement $\boldsymbol{\delta}$ is

$$\mathbf{F}\cdot\boldsymbol{\delta}=\sum_\alpha F_\alpha\delta_\alpha. \quad (3)$$

To present the equation of virtual work consider first a system of particles subject to internal and external forces. Let $\mathbf{F}^i$ be the resultant external force on particle i and $\mathbf{F}^{ij}$ the internal force on particle i acting along the line joining particles i and j. For the equilibrium of each particle i we have

$$\mathbf{F}^i+\sum_j\mathbf{F}^{ij}=0. \quad (4)$$

Now let the particle i be given an infinitesimal displacement $\boldsymbol{\delta}^i$ which is consistent with the constraints of the system but otherwise arbitrary. In particular the $\boldsymbol{\delta}^i$ may be independent of the force system $\mathbf{F}^i$. The $\boldsymbol{\delta}^i$ described is called a virtual displacement. Multiplying Eq. (4) by $\boldsymbol{\delta}^i$ and summing over all particles we obtain

$$\sum_i\mathbf{F}^i\cdot\boldsymbol{\delta}^i+\sum_i\sum_j\mathbf{F}^{ij}\cdot\boldsymbol{\delta}^i=0. \quad (5)$$

Eq. (5) is the equation of virtual work for a system of particles. The first term is the total external virtual work and the second term is the total internal virtual work. We recall that the negative of the work of a conservative force is defined as the increment in potential energy. Thus we

* Presented at the joint conference on Civil Engineering and Mathematics, S.P.E.E. meeting, St. Louis, June 20–23, 1946.

can transpose the second term of Eq. (5) and write

$$\sum_i \mathbf{F}^i \cdot \boldsymbol{\delta}^i = \Delta U, \tag{6}$$

where ΔU is the total increment in virtual potential energy.

Eq. (6) is valid not only for a finite number of particles but also for an infinite number and thus for any structure provided $\mathbf{F}^i$ and $\boldsymbol{\delta}^i$ have the meaning defined by Eq. (1) and (2). The form of ΔU depends upon the kind of stress involved, that is, direct stress, bending, torsion, or shear The formulas for ΔU can be calculated by Eq. (6) itself. If the $\boldsymbol{\delta}^i$ are produced by a load system $\mathbf{P}^i$ and the structure, for example, involves bending only then

$$\sum_i \mathbf{F}^i \cdot \boldsymbol{\delta}^i = \sum \int Mmds/EI, \tag{7}$$

where M is the bending moment corresponding to $\mathbf{P}^i$ and m is the bending moment corresponding to the $\mathbf{F}^i$.

The load system $\mathbf{F}^i$ can always be chosen so that the left side of Eq. (6) is precisely the displacement desired. For this reason the system $\mathbf{F}^i$ may be called the unit load system in analogy with scalar multiplication. It follows from the way in which Eq. (6) is used that the principle of superposition of displacements must be valid for the structure considered.

For a wide variety of structures it is possible to assume that the relation between the loads and displacements is linear. This relationship can be expressed very simply in terms of influence coefficients. The influence coefficient $C_{\alpha\beta}{}^{ij}$ is defined as the displacement at i in the direction α due to a unit load at j in the direction β. The α and β are the component directions at i and j. Thus the displacement components $\delta_\alpha{}^i$ at i due to the load components $F_\beta{}^j$ at j are

$$\delta_\alpha{}^i = \sum_{\beta, j} C_{\alpha\beta}{}^{ij} F_\beta{}^j. \tag{8}$$

Consider now two systems of loads $P_\alpha{}^i$ and $Q_\beta{}^j$ together with their displacements given by Eq. (8). We write the virtual work of $P_\alpha{}^i$ over the displacements due to $Q_\beta{}^j$ and also the virtual work of $Q_\beta{}^j$ over the displacements due to $P_\alpha{}^i$. For simplicity assume that the structure involves bending only. Then it is apparent from Eq. (7) that

$$\sum_{\alpha, \beta} P_\alpha{}^i C_{\alpha\beta}{}^{ij} Q_\beta{}^j = \sum_{\alpha, \beta} Q_\beta{}^j C_{\beta\alpha}{}^{ji} P_\alpha{}^i. \tag{9}$$

Since $P_\alpha{}^i$ and $Q_\beta{}^j$ are arbitrary it follows that

$$C_{\alpha\beta}{}^{ij} = C_{\beta\alpha}{}^{ji}. \tag{10}$$

Eq. (10) is a general statement of Maxwell's reciprocal law.

We can now derive Castigliano's displacement theorem based on the linear relationship of loads and displacements and Maxwell's law. In Eq. (6) let the $\boldsymbol{\delta}^i$ be replaced by the differential increments in displacement produced by the load system $\mathbf{F}^i$ itself. Thus

$$d\delta_\alpha{}^i = \sum_{j, \beta} C_{\alpha\beta}{}^{ij} dF_\beta{}^j. \tag{11}$$

Substituting $d\delta_\alpha{}^i$ from Eq. (11) in Eq. (6) we have

$$\sum_{i, j, \alpha, \beta} F_\alpha{}^i C_{\alpha\beta}{}^{ij} dF_\beta{}^j = dU.$$

Then by using Eq. (10) and (8) we obtain

$$dU = \sum_{i, j, \alpha, \beta} C_{\beta\alpha}{}^{ji} F_\alpha{}^i dF_\beta{}^j = \sum_{j, \beta} \delta_\beta{}^j dF_\beta{}^j. \tag{12}$$

The total energy U for the structure

can be expressed in terms of the loads $F_\beta{}^j$. Thus

$$dU=\sum_{i,\beta}\frac{\partial U}{\partial F_\beta{}^j}dF_\beta{}^j=\sum_{i,\beta}\delta_\beta{}^j dF_\beta{}^j.$$

Since the $dF_\beta{}^j$ are arbitrary it follows that

$$\delta_\beta{}^j=\frac{\partial U}{\partial F_\beta{}^j}. \tag{13}$$

Eq. (13) is a general statement of Castigliano's displacement theorem.

The virtue of the vector notation is its power of expressing an idea involving many details with extreme brevity. Thus it permits the instructor to present a general theorem at the beginning of a course with a resultant freedom to develop all its implications and possibilities.

Industry Requirements of Professional Agricultural Engineering Education

By J. D. LONG

President, American Society of Agricultural Engineers, Director of Education and Market Research, Douglas Fir Plywood Association

Agricultural engineering was born and nurtured to maturity by the industry it serves—agriculture. This is not unique in professional education, but it is indicative of the sound, conservative growth of the science and of the profession. The extent of its acceptance is shown by the estimate that 85 per cent of all agricultural research today carries at least some engineering implications.

Thirty land-grant colleges and universities now offer professional agricultural engineering curricula or the equivalent. Twenty-three institutions confer the B.S.A.E. degree, four confer a B.S.E. or have a major in M.E., C.E., or E.E. and three offer the work as a major in agriculture. In ten institutions the curricula is administered under the agricultural college, in nine it enjoys the joint administration of agriculture and engineering and in eight it is under the engineering college. Three departments offer two curricula each, one administered in agriculture and the other in engineering. This obvious lack of unity and educational objective, and the wide variations in curricula content are unsatisfactory and confusing for industrial employers.

Our teaching departments carry a dual load. They graduate professional agricultural engineers and offer service courses to students majoring in other agricultural sciences. Seventy-five per cent or more of the departmental teaching load may be in the latter category.

With heavy teaching schedules and small faculties compromises in curricula and classroom procedures have sometimes been made. Frequently these have operated to the detriment of the professional student training.

The American Society of Agricultural Engineers through its College Division Committee on Curriculums has worked on these problems for many years. Within recent years the accreditation program of E.C.P.D. has added incentive for resolving the difficulties.

Graduate Opinion Survey

Five years ago a subcommittee of agricultural engineers employed in industry was appointed to study the problem. Since technologists in this field were being employed in increasing numbers by industry, it was logical that the training requirements should be written for the graduates best qualified for this "market."

The subcommittee personnel comprised men employed in general agricultural engineering consulting practice, by manufacturers and suppliers of farm tractors, farm implements, chemi-

cals and explosives, electrical equipment and building materials, and by public service agencies engaged in research and field practice in similar lines and in farm products processing and soil and water conservation.

A survey of all agricultural engineers employed in industry was completed just as the war started. Opinions on the desirable and on the non-essential features of A.E. curricula varied over a reasonable range. There was general agreement that agricultural engineering must be an engineering curriculum qualified to meet all professional standards set for other engineers.

It was evident from the replies that the man in industry frequently finds that he profits less by WHAT he has been taught, than How.

For example, it was surprising to find a significant portion which expressed dissatisfaction with the mathematics instruction they had received. Other basic engineering courses were sometimes questioned. This is perhaps due to the courses being taught as abstract subjects rather than in a manner which would develop reasonable facility in practical application.

Not the least important of the suggestions was that the agricultural engineering department faculty must be alert to the subject matter being taught their students in other departments. A.E. students should find their problems and their potential contributions to the industry accepted in other technical fields.

Course Content

Content and presentation of all technical courses must be such as to develop professional pride, require creative thinking and encourage productive ability and social consciousness, as well as to merely impart theoretical and technical information.

Desirable subject matter courses for undergraduate study were segregated by the committee into five major classifications. All of them will not necessarily be offered in the curriculum at a given institution but a reasonable compliance was strongly urged. Industry must be able to depend on a more uniform "product" in hiring agricultural engineers if our graduates are to enjoy continued acceptance in commercial work.

Fundamental Courses

Fundamental courses include mathematics, physics and chemistry as essential tools of the engineer. Adding organic chemistry to the usual requirements was suggested as desirable since it enters some fields of agricultural engineering application. Botany and biology are necessary in work which has aptly been defined as "biological engineering." Accounting is basic to the cost consciousness which an engineer must develop. Effective speech and writing must be stressed throughout the curriculum—"Almost every engineer we hire is woefully weak in spelling, English composition and public speaking."

Basic Engineering Courses

Basic engineering courses start with drafting as the essential "engineer's language," with course content modified to include free hand technical sketching and mechanical drafting practices representative of current industry standards. Materials of construction can best be taught in the laboratory and shop, provided these are conducted as engineering production rather than as manipulative skill courses. Our graduates strongly favor

reorganization and increased emphasis on this phase of the curriculum; the fundamentals of labor relations, material specification and production cost accounting can best be based on such experience.

Descriptive geometry, analytical mechanics, surveying, fundamentals of electricity and structural design are included in the basic engineering work. Thermodynamics and hydraulics have applications in all agricultural engineering fields. Soil mechanics, taught as a combination of soils, physics and mechanics, is recommended as a special course for A.E. majors which should be conducted jointly by the agricultural and engineering faculties. Machine design and architecture are essential in specialized agricultural engineering fields but may be postponed for graduate study.

Basic Agricultural Courses

Basic agricultural courses recommended include agricultural geology, soils and fertilizers, agronomy, domestic livestock types and physiology and farm management. Dairy manufacturing and any other available food-processing courses are desirable electives. The geology, soils and fertilizers courses might well be prerequisites to the soil mechanics. Farm management is important in giving a basis for judging the relative importance of different farm capital expenditures and operation techniques, and in providing fundamental concepts of farm labor efficiency.

Agricultural Engineering Courses

Specialized agricultural engineering courses suggested start with a freshman orientation and problems course and an upper division seminar, and include required introductory courses in farm structures, field power, field machinery, soil and water conservation, rural electrification and farm utilities. Other specialized courses are recognized as being desirable where local conditions permit their inclusion. These might include food and fiber processing, rural community sanitation and pest control, farm safety and efficiency of farm production.

The usual conflict of opinion has developed between those favoring a broad fundamental course, such as has been outlined by the industry subcommittee, and the advocates of greater professional specialization in the undergraduate course. The former recommend that the specialized training in one of the major fields of agricultural engineering be secured by a fifth year of graduate work. The only solution of this problem perhaps is for each department to survey the market demand for their graduates and offer the type of training most preferred.

Requiring at least three months practical experience in agriculture and a similar period in industry prior to graduation was recommended in several replies.

Humanistic Courses

Social relations courses, including at least psychology, industrial economics, industrial administration, business and patent law, political science and history, were strongly recommended on the questionnaire returns. In addition to the usual arguments for such courses several voiced sentiments well expressed by one individual—"In dealing with people it is not sufficient to be right, you must persuade." Psychology, with emphasis on salesmanship, was especially recommended for the reason, "Regardless of whether one

enters commercial or academic work we are all salesmen in that we must sell ourselves and our wares to other people."

Several returns stressed the importance of college faculty members having experience in commercial work.

Summary

One paragraph from the committee report is a logical summary of their activity. "It is the potential productive capacity of the individual which makes him employable. Efficient work habits, constructive thinking abilities, creative imagination, willingness to accept responsibility, and cooperative attitude are on a par with technical knowledge as essentials for most industrial employees. Those college faculties which inspire their students in personality and character building, assist them in attaining a high degree of enthusiasm, confidence and technical ability, and inculcate in them high standards of professional ethics and human understanding will be producing graduates of greatest value to industry."

Why we Engage College Graduates for our Organization*

By G. A. WATERS

Chief Engineer, Wagner Electric Corporation
St. Louis, Mo.

General Comments

The Wagner Electric Corporation which was incorporated August 7, 1891, recognized in its early history the need of technically trained personnel to handle the responsibilities in connection with the design, manufacture, and distribution of its highly technical products. In the early years of the Company's history, no formally organized system was followed in the procurement of technical personnel. Forty years ago when the number of employees had increased to approximately 500 it was recognized that a systematic plan should be followed in the selection and training of university graduates particularly along engineering lines. Our plans in this connection have been changed from time to time to meet the prevailing conditions. Basically the system which has been followed is carefully to select qualified trainees and conduct a course of training, the object of which is to give the trainees an intimate knowledge of all of our manufactured products by training in our engineering, manufacturing, planning, sales, and service departments. This program is carried on under the supervision of a qualified member of our organization.

The details of this training course cannot be covered adequately in this short article.

Engineering Training Required and the Classification of Aptitude

The basic requirement for trainees is that they must have satisfactorily completed a four years course in an engineering school or university of accepted standing.

Most of our trainees are selected from graduates of courses in electrical, mechanical, metallurgical, or chemical engineering. When interviewing applicants an effort is made to select them on the basis of their aptitude for the various kinds of work they may be assigned to,—for example—sales work, engineering design, production work, application engineering with particular reference to our service requirements, etc.

Responsible Work for Which Technically Trained Men are Used

We have found it not only desirable, but necessary, that we have men with academic training along technical lines for supervisory and executive positions in our organization. Such men, who in our judgment of their performance in training, measure up to established

* Presented at the 54th annual meeting, S.P.E.E., Washington University, June 20–23, 1946.

requirements, are accepted as basically qualified for analytical study of all problems in connection with our activities, and, therefore, require a minimum effort on our part in training them for executive and official positions.

Result Obtained during Forty Years of Experience

While we conduct a training course which requires as a prerequisite that the trainees be college graduates, these trainees are not advanced to positions of responsibility over nongraduates who are equally qualified for the positions to be filled. It is interesting to note in this connection that some of our department heads have, through practical experience with the Company and extension work at Washington University School of Engineering and Architecture, qualified as technical experts and have successfully competed with college graduates who have satisfactorily completed the training course.

The President, two Vice-Presidents, and the Treasurer of the Company are all college graduates. One Vice-President and the Treasurer joined the Company before the apprenticeship system was established. The Production Superintendent is a college graduate who satisfactorily completed our apprentice engineering training. The General Sales Manager and Sales Managers of the various departments under his supervision are all technical graduates and most of them are past apprentice engineers. The Chief Engineer is a college graduate and is a past student engineer. Fifty per cent of the department heads in responsible charge of various engineering activities are college graduates and past student engineers. Ten per cent are college graduates without a student engineer training with our Company and forty per cent are engineers who did not have college degrees at the time they entered our employ but through technical development in their work with the Company and academic work in extension courses were able to successfully compete with college graduates.

Approximately seventy-five per cent of the personnel in our sales and service organizations are college graduates and most of these men are past student engineers.

From our experience in growing from a Company of 500 employees to 5,000, we have found that college graduates with supervised training along practical lines after graduation are not only desirable but necessary for an organization if it is to gain general recognition as a pioneer in its field and as a producer of competitive, quality apparatus.

Instrumentation*

By D. F. MINER

Assistant Director, Carnegie Institute of Technology

I have been asked to report to you some of the educational implications of the conference held at Carnegie Institute of Technology, October 16–18, 1945. The theme of the conference was "Instrumentation and the University," and the program grew out of discussions between faculty and members of the Instrument Society of America. The objective was to bring together various groups interested in instrumentation to discuss mutual problems, particularly in the field of education and training. The speakers were about equally divided between instrument manufacturers, armed forces and government agencies, other manufacturers and users, and educational institutions. Quite divergent opinions were aired and considerable discussion resulted from the papers presented. Although no definite program of educational procedure came out of the meetings, there was free exploration of the problems from all angles. Clear definition of the problems is the first step toward solution. Definite recommendations, made by several speakers, covered a wide range of possibilities. Some urged a complete college curriculum on instrumentation. Others believed very little could be done at the college level.

It is my purpose to summarize the various opinions and suggestions and add my own comments.

First, it is necessary to establish the background and importance of instrumentation, and next to examine the special educational needs that are involved. From the educator's point of view, is instrumentation just another collection of special techniques like air conditioning, material handling or television, or is it broader and more fundamental like ultra high frequency phenomena or fluid flow? If we recognize an educational gap or deficiency, then we can study what to do about it.

What is instrumentation? At one time there were listed 39 definitions, some simple and some complex. Here is one.

"Instrumentation is the philosophy based on (*a*) the proposition that the conditions of human society and of industrial processes and operations—i.e. the "forces of Nature"—should be controlled; (*b*) the principle that before a condition can be controlled, it must be measured; (*c*) the dictum that in order to measure a condition or property it must be segregated; (*d*) the slogan "If you control it manually you should control it automatically."

Some maintain that any method or equipment for indicating, recording, or controlling any property or phenomenon that varies with time involves instrumentation. Regardless of the exact definition, it is perfectly evident that instruments have become a necessary tool for man to use in developing

* Presented at the Conference on Electrical Engineering, S.P.E.E. meeting, St. Louis, June 20–23, 1946.

and controlling his surroundings. M. G. Hall cautioned that the word "instruments" means different things to different groups of people. To the doctor it means scalpels and forceps; to the musician violins or trombones; to the lawyer wills or contracts. But we are concerned with instruments which may be termed "industrial instruments."

Instruments have become necessary because of the limitations of the human senses. R. W. Gerard, University of Chicago, remarked that "man's knowledge is greater because his bodily senses have been so extended by his instruments. Collective man is certainly sensible to vast territories of the universe beyond those accessible to the individual. Not only the microscope and telescope, which extend spatial vision to the minute and the colossal; and the spectroscope, which extends 'color' far beyond the visible spectrum, but also electronic instruments which create or detect radio waves, X-rays, radioactive rays and particles, cosmic rays—or for that matter, the simple compass needle which detects a magnetic field—all inform us of phenomena completely foreign to man's biological senses."

It has often been proposed that we change or develop the human senses to encompass new areas. But it seems easier to develop technical devices to bring to our limited senses the information we need. Some very interesting comments were made by representatives of the armed forces. It was stated that we might have developed smaller faster planes or tanks if we had designed them for small men with specially developed senses, such as vision or balance. With drugs we might have changed the characteristics of fighting men to equal improved performance of many weapons. But we did not. We designed equipment for man as he is, with all his limitations. The problems of instrumentation then become very real. And in some areas we have not made the desired progress. For example, instrument flying is inherently unnatural and difficult. Yet we have not done what we could to simplify the instrument panels, the lighting contrast of dials, the figures and ranges. To a pilot the exact figures of engine temperature or oil pressure mean little unless he knows what value is too little or too much. Optimum range indications are preferable or a combination giving all horizontal or all vertical pointer positions for normal conditions would help. Instrumentation in planes depends too much on the one sense—sight. Commander Hibbard recommended more instrumentation based on sound.

Although war developments produced unbelievable achievements in instrumentation and control, new goals appear as fast as old ones are reached. Major J. G. P. Callahan described a few of the present demands and dreams of the Army Air Forces.

1. The measurement and indication of true airspeed of aircraft from 0 to 1,000 miles per hour and of missiles up to 4,000 miles per hour.
2. The measurement and indication of true height of aircraft above the sea level datum up to 80,000 feet and of missiles up to 80 miles.
3. A method for the determination and indication of the vertical in maneuvering aircraft.
4. A celestial ground position indicator for use in aircraft during day and night with an accuracy of $\pm$ 3 miles.

5. Methods of polar navigation.
6. Automatic indication of load balance in aircraft.
7. A simple remotely-indicating system for engine r.p.m., pressure, and temperature in aircraft.
8. System of measurement of fuel and oil quantity, especially accurate when the quantity is small.

Instrument manufacturers have made a practice of providing literature and engineering advice to customers to aid in the proper selection and use of instruments. Some companies have established courses of training for customers' employees. Others have set up a lecture service available to schools or industrial groups. All this has been inspired by competitive motives but has been aimed at giving the customer such services as he required. In spite of these efforts, it is apparent that these steps are insufficient. Customers' engineers often do not understand the instrumentation problems in their plants sufficiently to make a wise selection or specification for purchase. There must be more comprehensive and thorough training through some agency if the maximum benefits from instruments are to be obtained. This brings us to the point of asking what part should the university have in furnishing the needed training? Let us examine a few of the educational plans proposed at the conference.

(1) It was predicted by some that it will not be many years before a complete curriculum in instrumentation and control would be established in some colleges at the undergraduate level. Instrumentation engineering was compared in its growth to that of chemical engineering, which developed under chemistry and then came to be a field of its own. However, the demand for engineers trained in instrumentation as a major field is still small enough to prevent many schools from setting up a curriculum. The chances are slim that a student entering college will select with certainty what now looks like a restricted specialty, to follow a four-year course to completion, and to follow that occupational field after graduation. It was admitted that the day of a full instrumentation curriculum might be some time off, but in the meantime, less ambitious plans can be established.

(2) Several conferees agreed on the necessity of offering at least 2 to 4 semester hours' instruction in instrumentation in an engineering curriculum. Such a course or courses would be given in the upper two years on an elective basis. It was suggested that the program be divided into two parts —first a course in principles and second a laboratory course in measurements and familiarization with instruments. A successful instrument engineer develops considerable manual skill and needs to get the "feel" of devices with which he works. Another suggested arrangement of subject matter is one course in indicating and recording instruments; another in controlling, transmitting, and integrating devices. R. D. Webb suggested that an orientation course is needed for undergraduates on "Instrumentation Appreciation," confined largely to simple principles in the areas of pressure, temperature and fluid flow.

(3) A still different approach was proposed by several individuals. Instead of giving separate courses, introduce instrumentation into several courses; thoroughly saturate the regular electrical, mechanical, physics, and mathematics courses with problems of instrumentation, principles and methods

of analysis. Thus without giving specialized details of devices, the basic training could be given which would be a better preparation. Since it is generally admitted that there is no room in a 4-year curriculum for any appreciable specialization, the training in engineering fundamentals can include the fundamentals of instrumentation as well.

The employer cannot well give, and should not give, basic education. But it is his province and his obligation to provide the special training needed for a job. It would be convenient for an employer to hire a full-fledged engineer whom he could put right to work on a design or production job, but as Professor Clifford states: "A four-year course does not make you an engineer, but only an engineering possibility."

There is another reason related to lack of time, for insisting on teaching basic principles with very little specialization in a four-year course. Professor Jackson of M.I.T. once remarked that a young man in college can become very good, in four years, at learning fundamentals. After he leaves college, industry and society broaden his interests and teach him the reduction to practice of his fundamentals. But very few students ever add a single thing to their basic professional knowledge after they graduate. In other words, experience indicates that whatever basic principles a student learns must be acquired during his school years. The chances are against getting them later. This inevitably postpones the job of specialization.

Professor Kayan of Columbia believes that instrumentation is basic science and ranks with thermodynamics and fluid mechanics. Although not all persons would go that far, yet it is easy to recognize that some elements of instrumentation can be integrated with existing courses where appropriate. Mr. Fairchild, for example, suggested

a. Measurement of mechanical properties in the course on strength of materials.
b. Temperature measurement with thermodynamics.
c. Fluid flow measurement with fluid dynamics.
d. Microscopy with metallography and micro-chemistry.

(4) The need for instrumentation education is not limited to college students. Engineers and technicians now in industry are finding that they lack information and need training which must be taken while on-the-job. Mr. Ferguson proposed that the general plan should include these three parts.

a. Collegiate courses similar to proposals described above.
b. Short courses (four or five days) given at universities at convenient locations. These short courses would each be limited to a special field such as pyrometry, gages, electrical instruments, etc.
c. Correspondence courses covering instrumentation by industries, *e.g.*

steel,
refrigeration,
mining,
petroleum,
paper,
rubber,
etc.

(5) Supplementing college work in instrumentation, which should be on the basic principles level, practical work in industry was recommended. Summer employment in some application of instrumentation or in an instrument

manufacturer's plant may be more effective than laboratory work in instruments. It will also help to correct the deficiency caused by the unavoidable reduction or elimination of shop courses in college. Cooperative education programs can well be adapted to this combination scheme.

It is interesting to note what has already been done in some colleges toward training in instrumentation. Several colleges have conducted short courses or lecture series on special phases of instrumentation and control; for example, University of Oklahoma, West Virginia University and Case School of Applied Science. The attendance and interest were excellent.

To some people, the answer to the general educational dilemma of how to include fundamentals, social studies and specialization in a four-year course in engineering is to abandon the four-year course and admit it will take five years to accomplish the desired result. The present Ohio State curricula are planned on this premise. It is argued that some specialization is necessary for the graduate to get a job and be worth his salt to his employer. From the educational angle, theory without application is barren. A certain amount of illustrative practical material is necessary to bring theory to life and motivate the instruction. Those who are not convinced that a five-year undergraduate program is the answer may concede the value of a fifth year at the graduate level.

For many years, instrumentation has been a part of the mechanical engineering curriculum at Columbia University. It is taught in the regular courses on thermodynamics, fluid flow, etc. as a part of the subjects involved. It is treated as a fundamental element and not as special technologies. Both classroom and laboratory work cover instrumentation.

The Chemical Engineering Department at Worcester Polytechnic Institute has established an elective course open to seniors, covering principles and application of instruments to chemical processes.

At Massachusetts Institute of Technology, the graduate course in servomechanisms has attracted much favorable attention. Here a fundamental approach to control has been worked out in splendid fashion. D. P. Campbell states that "The science of automatic-control must be founded entirely upon the concept of studying the dynamical behavior of physical elements, physical systems and combinations of physical systems, elements and humans."

With all these various opinions, suggestions and practices relative to teaching of instrumentation in colleges, certain conclusions can be discussed.

1. It is perfectly evident that instrumentation for control of technical operations is a rapidly growing area. It is no longer a scattered collection of facts and methods, but is emerging as a definite and comprehensive body of knowledge implemented by highly complex devices and equipment. The time has arrived to recognize this special field. Recognition entails an obligation to consider the educational aspects. Shall we blossom out with special curricula as we once did for electric railways, for air conditioning, for automotive engineering and others, and as we are being pressed to do in radar, television etc.? Shall we dismiss the demand as another fad of the day? Or shall we recognize that the fundamentals of science and engi-

neering change only gradually and any new specialty can be served by existing fundamental training? The last seems the logical conclusion. There is at present no justification for adding another complete curriculum.

2. Broadly speaking, there is no room to crowd any new band of instructional material into a four-year curriculum. There is usually an opportunity, however, to make use of elective courses for special purposes. The principles and some simple applications of instrumentation can be offered in this manner. But no attempt should be made to develop skills and knowledge of techniques. This job must be left to industry through summer employment, cooperative courses, on-the-job training or industrial interneships. A. W. Carpenter, B. F. Goodrich Company, expressed this thought as follows: "The usual college course cannot provide the fundamental tools which he will need in all of the fields, and at the same time give him the degree of specialization which is required for mastery in a particular one or in any single industry. The latter must come after he enters the industry, through training on the job or through extension courses in the particular fields where his major interests lie." Where elective courses are offered, they might well be operated jointly by several departments, because instrumentation crosses departmental boundaries freely.

3. The soundest plan for the present seems to be the inclusion of instrumentation principles in regular courses in the engineering curricula. The suggestion to treat thermal measurement and control in the thermodynamics course and other similar correlations will accomplish the desired objective. Instrumentation then becomes part of the basic knowledge of engineering and avoids the specialization which does not belong in a four-year curriculum. A comparison may be made between the subjects of instrumentation and of laboratory methods. We do not have special courses in how to perform laboratory experiments, how to record data and draw curves. Such training is acquired in the process of laboratory work wherever it is found —chemistry, physics, electrical machinery, or electronics.

It will not be possible to add this integration of instrumentation in several courses without change in the existing material. Some modification will have to be made. This requires careful thought but is not too difficult. Many educators have found that careful study of course content and coordination with allied subjects will yield considerable space for a more thorough treatment of the areas covered or for a new approach to the desired subject matter. It seems to me that our task for the immediate future is to study the engineering courses we now have with a view to building into them as much of the principles of instrumentation as we can.

The Engineering Professor in a Society in Transition

By ALLEN H. BLAISDELL

Associate Professor of Mechanical Engineering, Carnegie Institute of Technology

A survey of the history of engineering education in this country reveals this institution as having been in a broad sense immune to the excitements of social change. In busily shaping the habits of youthful minds and hands to deal with the purely mechanistic needs of a rapidly evolving industrial nation the engineering educator seems to have exhausted his imaginative capacities. He was nevertheless a faithful servant to a society geared to fully exploit the natural resources of one of the most favored continents on the surface of the globe. But the war years of the present century, with their long trailing periods of world wide unrest, have jolted the engineering educator out of his pristine complacency; he is beginning more fully to sense his strategic position in the functioning of the national group.

Engineering schools, in company with other academic centers, have been conservative, stabilizing forces in the national life. Their intellectual interests were strongly centered in those branches of the natural sciences which dealt with the direct application of force, and the practical utilization of energy. Naturally enough the milieu of the engineering campus reflected, as it does now, a strongly materialistic atmosphere which enevloped the contemporary business and industrial groups of the nation. All too few of the outstanding leaders in engineering education, and likewise the rank and file, displayed any notable appreciation or interest in the human values inherent in the domains of poetry, art, drama, history, literature, or philosophy. Of what value were such in the workaday world? The answer has been, Just about zero.

All in all, those relatively placid and uneventful years composing the last two decades of the nineteenth century and the first decade of the twentieth century seemed to have offered little or no challenge to the engineering professors. Moderate, even mediocre teaching standards made it possible for men of very ordinary abilities to hurdle most instructional obstacles. Many such individuals possessed only the limited educational background afforded by four years in some one of the many engineering colleges, to which in some cases could be added a few years of limited engineering experience. Such was the customary and only preparation deemed necessary for acceptance into an engineering faculty. Once within the fold, the path of advancement was rather closely defined. Ability to handle large classes and heavy teaching schedules, without undue complaint from the students, supplemented by the publication of a few

papers in the professional engineering societies or the writing of a textbook or two during vacation periods served as the more immediate desiderata for elevation to full professorships. Instructional techniques suitable to rote learning were emphasized, but relatively little accomplished toward development of genuine understanding of imaginative capacity.

The comparative drabness of those years in engineering education is sharply defined when contrasted with the perplexing, yet tremendously stimulating conditions of a new day, and generation. True enough, the present educational problems which have grown out of military demobilization and the endeavor to fulfill obligation for providing a college education for any returned soldier who desires it may retard somewhat the strong pre-war trend toward making the best engineering schools more thoroughly scientific in character, and more effectively oriented toward studies of a humanistic and social description. One can reasonably guess that the admission of great numbers of students into our colleges and universities will tend to place emphasis on the more vocational aspects of the curriculum. It is not illogical to surmise that a policy of continued federal support may come out of the present situation, and in that case there could evolve a system of higher education more closely allied to the high school system in sympathy, objectives, and methods, than has been the case up to the present time.

The engineering profession is rapidly growing aware of its strategic position among the groups supervising and directing the operations of the nation's industry. The latter, driven by the spur of widespread and intense labor union activity directed toward marked changes in the general economic status of the laboring man and by high government taxation, must seek in every legitimate manner to forestall the threat of eventual socialization in the form of government ownership. Intelligent management is striving to improve in all ways possible the working environment of its employees, to maintain a wage system commensurate with the prevailing living standards, and to develop a strengthened form of insurance which will serve to adequately relieve or remove the insecurities of sickness and old age. But all this activity directed toward personal welfare must of necessity be accompanied by an equally energetic procedure to insure the prospects of a reasonable profit from enterprise.

There are unmistakable signs of an accelerated trend toward replacement of human labor by ingenious forms of mechanical equipment. The extent to which this movement is successful in its objectives will be dependent on the reactions of the labor unions. It is conceivable that without a rapid development of new forms of industrial activity a collective effort of the labor unions on a national scale can throttle or seriously slow down all efforts directed to effective mechanization of industry.

Aside from these historically familiar industrial ills there looms up the threat of our inability to replace dwindling sources of raw materials with adequate supplies from foreign lands. Added to this the eventual reduction in our export business due to the establishment of a formidable manufacturing system in the Russia-controlled countries of Europe and Asia affords no consolation to the industrial leaders of the nation. At the moment, both national and world-wide conditions of every descrip-

tion are so confused and uncertain that the very existence of industry in the United States in the form of independent enterprise is rapidly approaching the state where leadership, both business and scientific, must be of the highest quality. The primary source of this leadership resides in our colleges and universities, and this means that educators, individually and collectively, are going to be forced, willy or nilly, to assume responsibilities commensurate with a task imposed by a nation at the crossroads of its destiny.

The engineering teacher, therefore, in company with his associates in other branches of higher education, is really faced with educational problems demanding more than ordinary qualities of mind and character. And this applies in both undergraduate and graduate instruction, with of course some variation in emphasis. Postgraduate instruction in the sciences which are applied in engineering really demands that the instructor shall be a technical scientist sufficiently familiar with higher mathematics, scientific data, and the techniques of research that he not only can guide student investigations but also carry on his own experimental studies and thereby add to the existent fund of scientific knowledge. In view of the extensive and widespread activities in scientific research it seems evident that the postgraduate teacher must first of all be a specialist.

Contrariwise it would seem as though the bulk of undergraduate technical instruction should be conducted by men possessing a reasonably thorough scientific training, more thorough than has been the case in years past. This could well be supplemented by a few years in industry before the actual teaching career is initiated. The formal education of these teachers, although primarily scientific and technical, must be effectively articulated with studies in the domains of philosophy, history, literature, art, drama, etc. Expressed in other terms, if many publicized educational aims are such as to stress the dire need of broadening the outlook of engineering graduates, isn't it equally evident that such objectives are consonant with the fact that the engineering teacher, certainly insofar as undergraduate instruction is concerned, must possess a much better integrated, synthesized fund of learning than has generally been conceived as possible, or even needed.

In brief, since the bulk of engineering graduates will likely never receive more than four, or five at the most, years of college or university instruction, it seems reasonable to suppose that such instruction should be placed in the hands of teachers who are not specialists, but men of general scientific knowledge, broad and sympathetic outlook, as well as sustained interest in the activites of the engineering profession. Possibly one might add that the less instruction the undergraduate student receives from pronounced specialists of any kind, the less unbalanced his basic education. Soon enough, all too soon it may be, the young engineering graduate is introduced to the atmosphere of the specialized activities of his chosen profession, and thenceforth he is subjected to daily associations and experiences which have a strong tendency to shape his mentality into the groove-type of the professional man.

Those qualites of vision which we feel absolutely necessary for sane and safe leadership in the general activities of our nation can never flower in any kind of dogmatic atmosphere, even if it be that of pure and applied science, or conversely that of the so-called hu-

manities. Expressing this in a very broad way, the engineering student must be strongly fortified to face a society in which the advance in science and technology has dangerously outstripped its moral evolution, particularly in the form of human relationships. He must be trained to survive the social weather of times strongly charged with suggestions subtly introduced into newspapers, magazines, books, etc., which are doing much to produce conviction unsupported by fact or intelligent comprehension.

We may summarize the above aspects of the undergraduate problem by stating that no form of education for this class of students, engineering or otherwise, is sound which does not place strong emphasis on the effective stimulation of those qualities of mind and character which share to such an extent in the development of imaginative sympathy and appreciation, combined with a high degree of self-control and clear thinking.

The development of undergraduate engineering courses directed toward providing students with a better chance to secure an integrated knowledge of scientific principles, will necessitate a marked improvement in instructional procedures. The transfer of all, or nearly all, specialized instruction to the senior year, and much of it to a fifth year in many institutions, will remove a source of much of the student motivation which has served in the past to make instruction in the engineering departments relatively easy compared with that carried on in the basic courses.

Sufficient recognition is never given to the fact that most engineering students come onto the campus with a strong bias concerning their ultimate objectives. These predilections are determined and colored by the home environment, by participation in the activities which have assumed so important a position in the nation's public school system, and by the influences of friends and relatives. The notions, ideas or viewpoints which grow out of these early associations are so strong and stubbornly held that it is only with the most careful and sustained effort of admission officials and instructional staffs that the sometimes desirable re-orientation of the student mind can be successfully achieved. We must understand that by the time the American youth has completed his sixteenth or seventeenth year of life, he has been subjected to an educational process of the most thorough description. His character and mental processes are, for the most part, set once and for all, but his critical faculties have been ignored. It is only under the most unusual of circumstances that higher education can be expected to do much more than scratch the skin of a case-hardened personality.

The reflections presented in the foregoing paragraphs are in more or less general circulation among engineering educators, but existing conditions make it exceedingly difficult to give them much more than lip service. In engineering undergraduate education, the demands on the teacher's time can be, and usually are, heavy indeed. Regardless of pedagogical efficiency the engineering schools are at the mercy of current ideas concerning the factors which really identify meritorious attainment in professional education. Certainly the highly important intangibles previously referred to do not figure very prominently in the picture insofar as the general public is concerned.

When viewed from a broad standpoint, the problem of effective undergraduate instruction appears to be far from solved. What is more to the point, as recent ideas on course objectives and content are put into practice the prevailing poverty of ideas concerning suitable instructional techniques and objectives will reveal themselves in the possibility of a severe retarding of educational advances, if not in a complete annulment of desired ends. Another disquieting thought materializes when one observes the widespread and by no means recent tendency to attach exceptional value to advanced academic degrees which are so often the fruit of inconsequential research activities, and by no means the most reliable indicators of intellectual endowment or creative capacity. But, in all fairness, we must recognize other facets of the situation. The financing of educational ventures has become a problem of no mean magnitude. Seldom, if ever, are the operating expenses of higher education fully met by tuition fees, for which reason additional funds must be secured from outside sources, such as alumni and friends. However, this financial assistance is only forthcoming if an engineering or scientific institution is sufficiently successful in securing wide publicity through its research publications. The privately endowed schools are particularly exposed to this need and therefore find it most imperative to secure and maintain a lively public interest in their work. Just so long as the excellence of an educational institution is measured mainly by its output of research publications, just so long will it be necessary to emphasize this phase of educational activity beyond its proper deserts. There seems to be no choice. One feels like posing the question if discovery of truth should not also be supplemented by the occasional creation of truth.

The writer recognizes, and is strongly inclined to the belief that the proper place for the training of very young scientists is in the academic atmosphere where complete freedom of imaginative venture can be maintained free from the constraints (however light) of the prevalent industrial world. A limited number of well-favored and centrally located schools must serve as the primary feeders to the personnel of the great scientific laboratories which have served the nation so well. As mentioned before in this paper, these embryo scientists require the attention of teachers who have thoroughly demonstrated their inherent ability to sense the possibilities of discovery in the several domains of pure and applied science, and who also have a natural inclination to assist young men in their endeavors to become productive research scientists. Postgraduate education with this end in view is of great importance and merits the utmost consideration. But the cost of operating satisfactory graduate programs in these modern days is a very serious matter. The strenuous attempts of industry to entice promising young scientists into their employ make it very difficult, oftentimes impossible, to bring such men onto the engineering campuses because of the relatively low financial compensation obtainable. And yet, without such outstanding talent, it is absurd to expect very much in the field of solid achievement in scientific research.

There are a few institutions of wide reputation that have been reported as nursing their graduate activities at the expense of the undergraduate work. An excessive utilization of graduate

fellows in undergraduate instruction has been rather common practice, and the renowned research professor has only exposed himself to the undergraduate attention on relatively few occasions. These facts are rather well known, and on the whole accepted as the fruits of a customary and accepted practice. The faults inherent in such procedures are of course appreciated, and one can hardly imagine that such situations will be allowed to develop to more than a very limited extent.

Common sense would seem to indicate that the highly trained and specialized scientist will not, of necessity, achieve spectacular results in his efforts to instruct undergraduates unless he is fortunate enough to lecture in the field of his specialty. Even in such cases history discloses that it is only the very unusual individual who possesses the sympathy of understanding which will lead him out of his specialty down to the mental plane of his students who will naturally have only a very general interest in whatever knowledge he may be in a position to supply them. When it happens that he is assigned to instructional duties of a more general nature, the specialist is placed at a disadvantage as compared with the teacher possessing a broader background and a more diversified experience in teaching. In fact, few men can successfully carry on scientific research without an enthusiasm and intensity of interest in their purely personal problem which in most cases cannot fail to dim their interest in the learning difficulties of their students, if the latter happen to be outside the graduate group.

The thread of thought which has been carried through the present discussion has dealt more or less specifically with the real importance of effective instruction in the undergraduate education of the engineer. The problem is one of exceptional importance and its solution will not be achieved without an extended period of experimentation involving a great deal of trial and error, frustration and disappointment. Only a vision sustained by convictions of the most determined and courageous kind can be expected to cope with the resistance inherent in a long established and rigid educational practice.

Teaching the Break-Even Chart*

By CLARENCE E. BULLINGER

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In the study of engineering economy, it is necessary for the teacher to develop the following concepts:

1. First cost.
2. Working capital.
3. Total investment.
4. Fixed operating cost.
5. Variable operating cost.
6. Total operating cost.
7. Income.
8. Capacity or rate of operation.
9. The financing of the project, through
   - *a.* Bonds.
   - *b.* Preferred stock.
   - *c.* Common stock.
10. The expected returns for the several elements of financing.
11. Federal income taxes.

The student of engineering and even the engineer have a predilection to desire to have the above concepts brought together into an equation. His whole training has led him to believe that he could put into a formula almost any relationship that he may think of.

I know of no easy way to bring together the above elements of an economic situation into a formula except that of the break-even chart. It is in effect a graphical formula. Its usefulness can be demonstrated in that it permits the one using it to study the present economic position of his project and also to project onto it changes that may occur from time to time in its elements. The projection of such changes on to it will be used by the engineer to arrive at the necessary adjustments which must be made in order to keep the project a going concern.

The engineer uses formulae to assist in doing his work but he does not use them alone to the exclusion of his ability to analyze, compare and synthesize his many problems. I am suggesting that the engineer should know his formulae not only from one angle but from all angles. If one of the variables in the formula changes, he should be able to say almost immediately what will happen to the other factors in it.

Some people might say that the "balance sheet" is such a formula. Or perhaps, they may suggest that the "profit and loss" statement is one. They are in fact formulae but somewhat limited in that they are unable to include all of the cost factors in a situation. The balance sheet does not reveal operating conditions and the profit and loss statement does not include investment. Even when taken together they do not reflect the factor of "capacity."

I wish to suggest that what I call an "operating cost diagram" will bring together into a "visual formula" all of the cost factors that are needed to

* Presented at the Engineering Economy Conference, S.P.E.E. meeting, St. Louis, June 20–23, 1946.

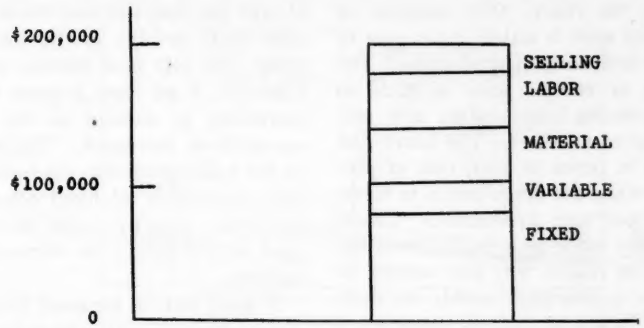

FIGURE 1.

40% capacity. 20 M units.

understand an economic situation. It is simply a "break-even" chart to which has been added an additional chart giving the same information in units.

The cost part of a profit and loss statement can be graphically shown in Fig. 1.

It is not complete unless coupled with it is a statement of capacity or rate of operation. By itself, therefore it is inadequate as a formula. Since similar diagrams can be made for various rates of operation, the placing of them side by side will give a better view of the relationship between operating cost factors and capacity. In fact this chart is a flexible budget. By connecting the top mid-points of these figures and adding certain scales the foundation for an operating cost diagram has been formed. See Fig. 2.

The chart is constructed by first setting up a gridiron upon which may be drawn or indicated the essential

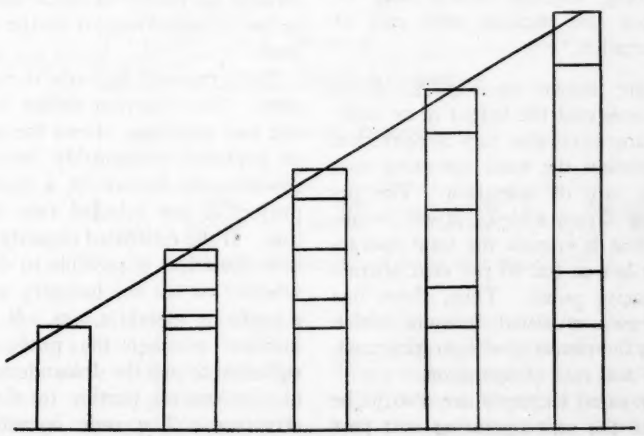

FIGURE 2.

parts of the chart. The abscissa or horizontal scale is stated in per cent of capacity and units of production. The ordinate or vertical scale is stated in total operating cost dollars and unit operating cost dollars. The lower diagram is in terms of total cost of production while the upper one is in terms of cost per unit production. Charts are usually made on a yearly basis, but there is no reason why they cannot be made on a monthly, weekly or daily basis. They may even be made on a product or project basis.

The visual formula may now be constructed by adding the elements or factors in the cost situation:

1. Fixed costs, which includes costs which do not vary with the rate of operation.
2. Variable costs which include indirect labor and materials, and costs of other items that vary with rate of operation.
3. Labor which varies with rate of operation or production.
4. Materials which vary with rate of operation or production.
5. Selling expense which may be fixed and variable with rate of operation.

These are shown on Fig. 3. It is readily seen that the height of an ordinate at any particular rate of operation will represent the total operating cost for that rate of operation. The income line is now added. It will be observed that it crosses the total operating cost line at the 40 per cent operating capacity point. Thus, there has been drawn a visual formula which contains the elements of operating cost, income, and rate of operation.

These same elements are also to be added to the unit operating cost part of the diagram (the upper diagram). It will be observed that those factors that were variable in the total operating cost part now become constant. Likewise, fixed costs become variable, increasing in amount as the rate of operation is decreased. This is based on the assumption that the business expects to absorb all fixed costs at the particular capacity point without regard to the extent of idleness of the facilities.

It must not be assumed that such a diagram drawn with nice straight lines is found in every industry or in every economic situation. In many situations the total operating cost line is a curve, curving upwards from the left to the right and of a somewhat parabolic shape.

The visual formula is still not complete because there is nothing in it having to do with capital structure or investment. For convenience, Federal income taxes are added first, since they may be considered as a first obligation to be paid out of earnings. See Fig. 3.

Next will be added the returns or payments on bonded debt, followed by returns on preferred stock and finally by the expected return on the common stock.

The graphical formula is now complete. The diagram unlike the profit and loss statement, shows the estimated or expected relationship between the several cost factors in a business or project at any selected rate of operation. If the estimated capacity position is indicated, it is possible to determine whether or not the industry will make a profit or sustain a loss. It will also indicate whether the profit will be sufficient to pay the demands and hopes of the several parties to the capital structure. The unit operating cost part of the diagram will reveal what the

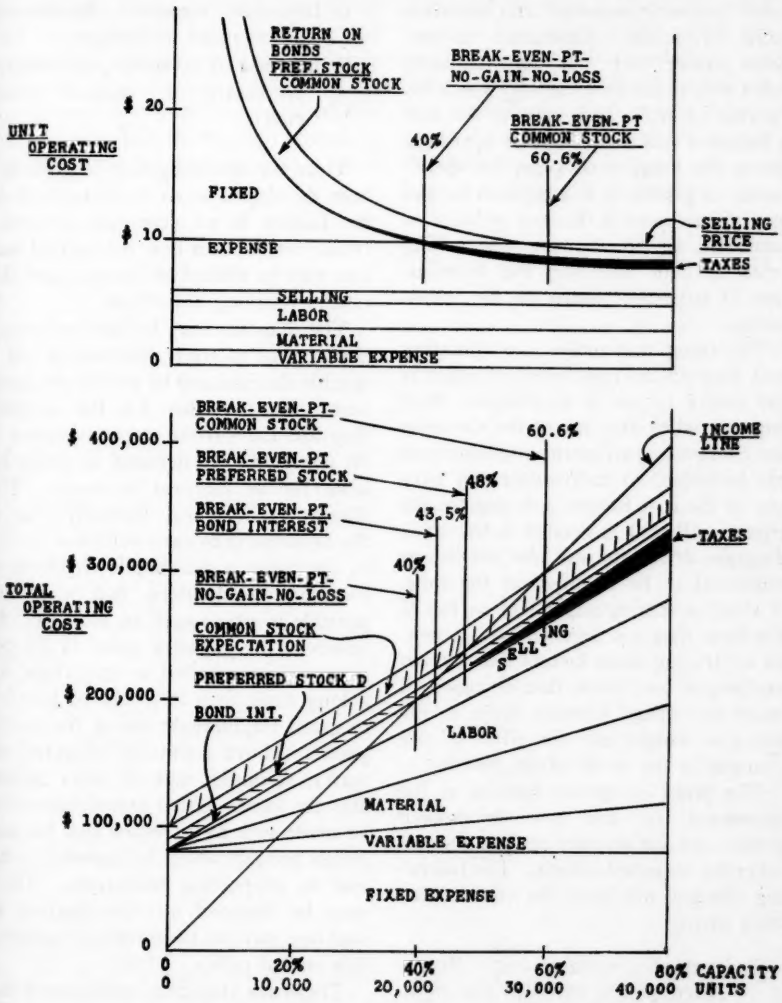

FIG. 3. Operating cost diagram or break even chart.

selling price should be to accomplish these demands and hopes.

The intersection of the income line with the total operating cost line and the top line of common stock expectations is an important guide post to an evaluation of the situation. In the diagram Fig. 3, it will be seen that at the 40 per cent capacity point, this business will just break even, but that at the 60.6 per cent capacity point there will be sufficient profits to take care of taxes,

bond interest, preferred and common stock dividends. Operation at any point above 60.6 per cent capacity point will result in what may be called "excess profit." It is easy to see that a business that has a rate of operation above the break-even point for distribution of profits, is in a position to take care of increases in the cost of labor or materials, or to decrease the selling price without affecting the distribution of expected return on the invesments.

The thing that makes the operating cost diagram an instrument of value is the ability to use it to discover what happens when any one of the elements are changed. Just as the engineer uses his formulae, so individuals can vary any of the cost factors and observe the effect. All that is needed is the basic diagram drawn to suit the conditions estimated to be in effect at the time. A sheet of tracing paper laid on top of the basic diagram together with a pencil for tracing those factors that remain unchanged and those that change will make this visual formula come to life and give insight into the effect of any changes in any or all of the factors.

The point of special interest is the movement of the two break-even points, one for no-gain-no-loss and the other for expected-return. The following changes will have the effect noted after them:

1. Increase a variable cost. Break-even points move to the right.
2. Decrease a variable cost. Break-even points move to the left.
3. Increase a fixed cost. Break-even points move to the right.
4. Decrease a fixed cost. Break-even points move to the left.
5. Increase income. Break-even points move to the left.
6. Decrease income. Break-even points move to the right.
7. Increase or decrease productivity. Necessary to redraw whole chart.

Thus, the operating cost diagram has been developed so as to include all of the factors in an economic situation. It has been shown how the several factors may be altered or changed and the results deriving therefrom.

The diagram may be used at a particular time to study whether or not a specific demand can be met by the business. Assume that for the original diagram the current capacity point is 50 per cent. A demand is made by labor for an increase in wages. The diagram will reveal instantly that if the business is to earn sufficient profits to distribute a reasonable dividend to common stockholders, that it is impossible to grant such an increase. If, however the capacity point is 73 per cent and is expected to stay there for a long time, then it would be possible to grant the increase out of the excess profits (above estimated expected return), assuming that all other factors stay the same. Other assumptions may be made such as increased cost for materials brought about by a general wage rise in supporting industries. These may be imposed on the diagram so that one may see the effects of adopting this or that policy.

There are numerous refinements that may need to be made in order to make the diagram useful in many diverse situations. When a business has many products produced in varying amounts, adjustments may be made to the scale for production to take care of the fact, usually by means of index numbers.

The diagram is not intended to be

an accurate device correct to the penny but as a medium for visualizing the actions and interactions of the economic elements in a situation. Essentially it is a geometrical formula so devised that the several factors be they fixed or variable may be illustrated as a basic situation in time. Then by using a piece of tracing paper and pencil, one is able to re-draw in a relatively short time the impact of changing values of the several cost factors in a situation. It is the engineer's tool for economic analysis.

Predictions of Average Class Achievement by Means of Aptitude Tests*

By WILLIAM C. KRATHWOHL

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Just before the beginning of World War II, an investigation by means of aptitude tests was made of classes in mathematics at the Illinois Institute of Technology to answer the question, "Is it possible to predict, before an instructor meets his classes, whether such classes will turn out to be good, medium or poor?". As a result of this investigation a number of other facts were discovered: (1) the reason that many students have difficulty with mathematics, (2) the reason that certain types of classes are more difficult to teach than others, (3) the reason that students drop out from an engineering school, (4) the consistency with which instructors grade their classes, and (5) a suggestion for evaluating teacher efficiency.

The classes which were investigated were those in five courses: review algebra, which is a refresher course in high school algebra, college algebra, analytic geometry, and the two courses in calculus. The test which was used was the Iowa Mathematics Aptitude Test. Other tests also could have been used, particularly mental ability tests and the various tests known as psychological examinations. It was found that the criterion for the best test to use is the size of the correlation coefficient when average grades are compared with average test scores.

The technique which was used was that of comparing average class grades with average test scores.* In order to make such a comparison, it was necessary to change average class grades to numbers. This was done by letting the letter grade A equal 3, B equal 2, C equal 1, D equal 0, and E equal -1. The grade of A is awarded for superior achievement, B is given for performance just above the average, C is an average grade, D is a poor pass, and E is a failure.

The average test score was found by averaging the derived scores which the students received in the mathematics aptitude test. Derived scores have a mean of 20 and a standard deviation of 4. Other scores could have been used, such as raw scores, scaled scores, and sigma scores, provided they are linear functions of the corresponding raw scores. Percentile ranks, because they are not linear functions of the raw scores, cannot be used.

After the five figures of the five courses were constructed, conclusions

* Presented before the Mathematics Division of the S.P.E.E. at its annual meeting in St. Louis, June 1946.

* Krathwohl, W. C., "A Simple Method for Comparing the Achievement of Classes with Their Ability," *The Journal of Educational Psychology*, XXXV: 248–253, April, 1944.

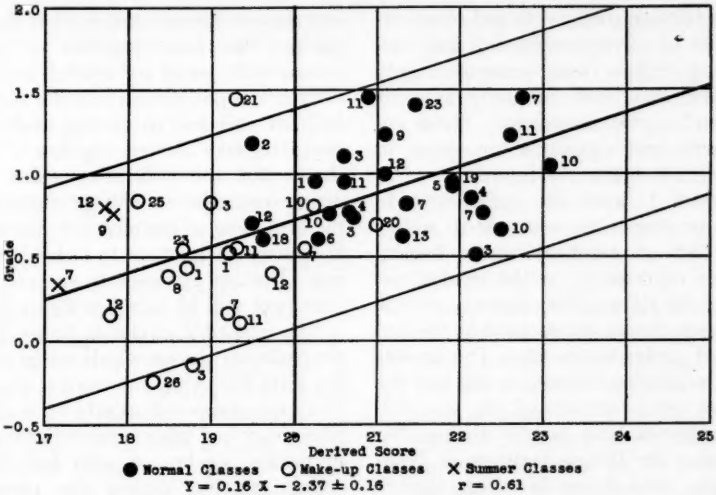

FIG. 1. College algebra grades with mathematics aptitude scores.

were drawn by examining each figure separately and then seeing how far such conclusions could be applied to the remaining figures. This method will now be explained for each figure.

Figure 1 shows the scatter diagram which is obtained when average college algebra grades are compared with average scores in the mathematics aptitude test. Each circle or cross represents a class varying from 15 to 40 students. The shaded circles represent normal classes, the unshaded circles represent make-up classes, and the crosses represent summer school classes. Normal classes are defined to be those classes which a student takes if he enters properly prepared and has no failures. Thus the normal student takes college algebra during the fall term of his freshman year and analytic geometry in the spring term. In his sophomore year he takes calculus I, which is beginning calculus, during the fall term and calculus II or integral calculus in the spring term.

The make-up classes follow one term behind the normal classes. They are for the most part composed of students who are repeating a course because of receiving a D or an E in it or who are a term behind because of the necessity of taking a refresher course in high school algebra.

The numbers near the circles and crosses are the code numbers of the instructors. They are chosen so that full time instructors have numbers from 1 through 19 and graduate assistants and part time teachers have numbers from 20 to 40. Instructors are given the same numbers in all figures.

The heavy diagonal line is the line of regression of average class grades against average test scores. The lighter lines, running parallel to the line of regression, are situated at a distance from it equal to three times the standard error of estimate, measured parallel to the y-axis. Classes outside these parallel lines are there for reasons other than errors in sampling.

Correlation coefficients and equations of lines of regression for this and succeeding figures were computed only for full time staff members and for fall and spring semesters. These coefficients and equations are given in the legends below the figures.

Figure 1 raises the question as to why the classes are scattered so widely from left to right, with the normal classes represented by the shaded circles to the right of the diagram, and the make-up classes represented by the unshaded circles to the left. The answer to this question is found in the way the classes were formed and the way college algebra was taught during this period at the Illinois Institute of Technology. The classes in college algebra were formed by the registrar, who took students at random without regard to any test scores. At the beginning of the term it was found that all normal classes clustered around the line $x = 20$. This is where they should be since the mean average mathematics aptitude score is 20. During the first five weeks a review of high school algebra was given and students were tested every week. After each test those students who failed were told by their instructors that their training in high school algebra was too inadequate for them to take college algebra successfully. They were then advised to take a refresher course called review algebra, which reviewed in one term the high school algebra which they had covered in three. Most of the failing students volunteered for the course. Had the real reason for their inability to handle algebra been poor high school teaching instead of lack of aptitude, the normal college algebra classes would have remained about the line $x = 20$. Instead, as time went on, the normal classes represented by the shaded circles moved further and further to the right. The final position of these classes was found to depend both on their initial position and on the success an instructor had in getting weak students to take review algebra. This shows that the difficulties which students encounter in college algebra at the beginning of the term are due more to lack of ability than to lack of training. Further evidence to support this statement will be found in figure 2.

The unshaded circles in figure 1 are the make-up classes which are given in the term following the normal classes. They are composed mostly of students who either had taken a refresher course in review algebra or who had failed college algebra during the previous term. Figure 2, which follows, will show that the classes in review algebra, from which the greater part of the make-up classes come, are composed largely of students who have low scores in mathematics aptitude. This explains why most of the make-up classes have a position in the scatter diagram to the left of the normal classes.

Another item from figure 1 that should be noted is that the make-up classes in general not only receive lower average grades than the normal classes, but also that more of them lie below the line of regression than lie above it. This characteristic seems to persist up through the calculus courses. Evidently, even an extra term of instruction in elementary algebra is not sufficient in general to bring classes with low mathematical ability up to the level of achievement of normal classes.

The crosses which represent the summer school classes at the extreme left of figure 1, have even lower average mathematics aptitude scores than those of the make-up classes. Students usually take summer school work in-

stead of working during the summer because their grades are so low that this is a last desperate effort to remain in school.

In addition to the fact that the difficulties students have in college algebra are due more to lack of ability than to training, several other conclusions can be drawn from figure 1.

1. Because the correlation coefficient between average grades in college algebra and average test scores is fairly high for correlation coefficients in the field of education, it is possible for an instructor, before he meets his class, to estimate its quality. If his class is good, he can prepare himself to enrich the course. If his class is poor, he knows he will have to work harder to get the subject across.
2. An examination of the location of classes taught by graduate assistants and part time instructors who have code numbers of 20 and higher, shows that they are usually found on the boundary of the scatter diagram. Their location may be due to their inexperience both in teaching and in grading but is more likely to be due to lack of understanding of what is expected of them. Had graduate assistants been included with the full time faculty members in computing the correlation coefficient in figure 1, its value would have dropped from 0.61 to 0.54.
3. Summer school classes in this figure and in those to follow are almost invariably above the line of regression. The reason for this may be either because of better work on the part of students by taking fewer courses or because standards in the summer school tend to be lower than in the regular school. Possibly both causes operate.
4. An instructor can tell from a diagram like figure 1, how closely his grading standards approach those of his colleagues. If his classes lie close to the line of regression, he

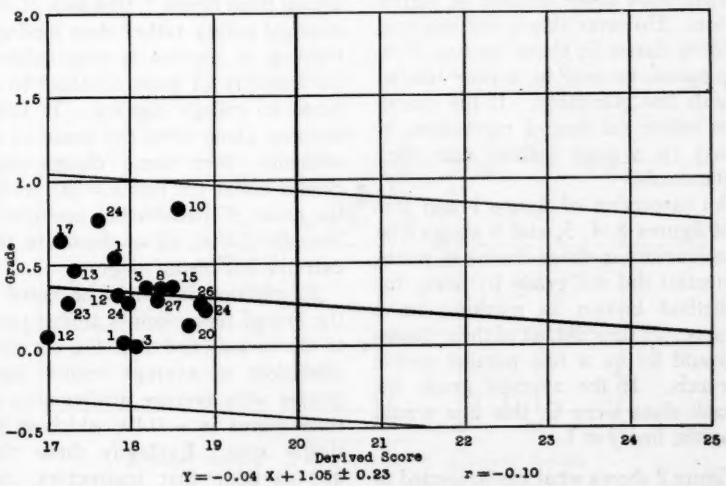

FIG. 2. Review algebra grades with mathematics aptitude scores.

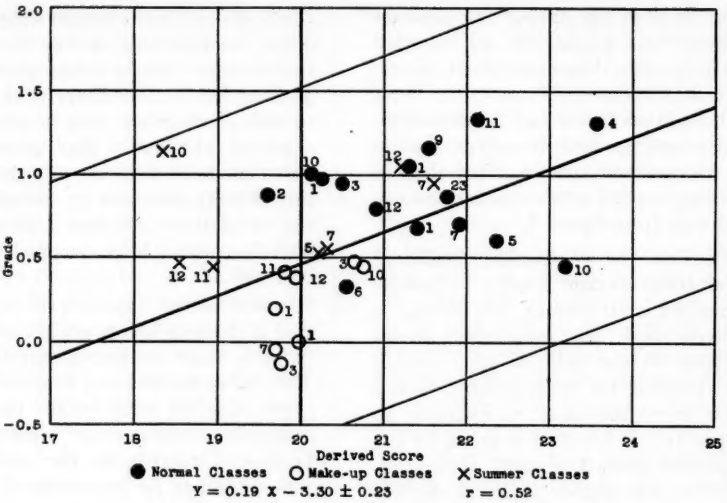

FIG. 3. Analytical geometry grades with mathematics aptitude scores.

grades the same as his colleagues. It might also be thought that he could tell from this figure if he were a better instructor than his colleagues by noting if his classes always were above the line of regression. However this is not the case. If his classes lie above the line of regression, he may be a poor teacher with low standards. If his classes lie below the line of regression, he may be a good teacher with high standards.

5. An inspection of figure 1 and also of figures 3, 4, 5, and 6 shows that instructors in these classes in mathematics did not grade by using the method known as marking on a curve. If they did, all of their classes would lie on a line parallel to the x-axis. If the average grade for each class were C, this line would be the line $y = 1$.

Figure 2 shows what has happened to those classes which were formed of students who because of their poor work in the first few weeks of the college algebra course volunteered to take a review course in high school algebra. This figure verifies the conclusion drawn from figure 1, that lack of mathematical ability rather than inadequate training in algebra is responsible for the inability of most students to continue in college algebra. If lack of training alone were the cause of their difficulty, then these classes should cluster about the line $x = 20$, which is the mean of mathematics aptitude test. Instead of this, all of them are at the extreme left of the diagram.

In addition it should be noted that the line of regression is almost parallel to the x-axis and that the correlation coefficient of average review algebra grades with average mathematics aptitude scores is -0.10, which is practically zero. Evidently these classes are so poor that instructors, rather than fail most of their students, marked

on a curve with an average half way between a C and a D. Some of these students were given passing grades and they enrolled in the make-up class in college algebra. Hence, it is not difficult to see why the make-up classes are so difficult to teach and why students in them do so poorly.

In figure 3 which compares average grades in analytic geometry with average scores in mathematics aptitude, one thing stands out clearly and that is the shift of the scatter diagram to the right. Many students drop out at the end of the first term of college, and it is not difficult to see that most of those who do, have low mathematical ability.

The make-up classes again are to the left of the normal classes while the summer school classes are even further to the left. Furthermore, the make-up classes are all below the line of regression. The location of these classes in analytic geometry in this particular position seems to be more than an accident because several investigations made subsequent to this one have found that these classes are always precisely in this region. Several reasons have been suggested for their location. Among them are lack of competition with better students, prejudice of instructors, a sense of defeat or a spirit of saying, "Someone must pass, so why work?", but more likely the reason is the tendency for failing students to carry too heavy a load. There is an unfortunate opinion among many ad-

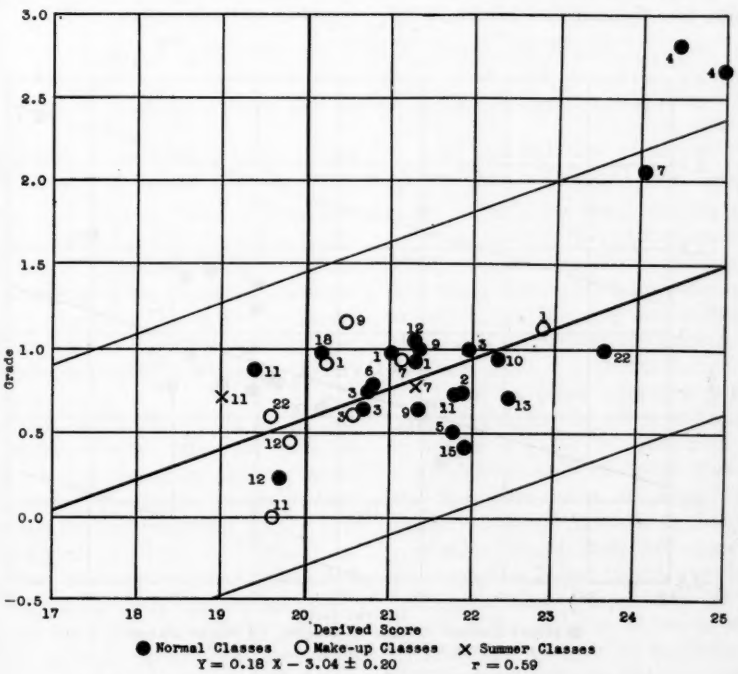

FIG. 4. Calculus I grades with mathematics aptitude scores.

ministrators that if a student has once been exposed to a course, it should be easier for him next time. These failing students, in an effort to catch up, often take more courses than they are capable of handling, whereas their load should be less.

The summer school classes again are above the line of regression. Whether this position is due to a lighter load or lower standards it is difficult to say.

The scattering of classes from left to right can be explained partly by the tendency of students even as early as the freshman year to form groups or cliques. Students with high mental ability tend to associate with others of like ability, and students with low mental ability tend to form groups with others like themselves. Hence, if students are allowed to select their classes such classes can vary widely in ability.

In figure 4 and figure 5, average class grades in beginning calculus and integral calculus are compared respectively with average scores in the mathematics aptitude test. In these two figures, the classes in the extreme upper right hand corners, taught by instructor No. 4, are experimental classes formed from volunteers who had received very high grades in their freshman mathematics courses and who were given the inducement of studying special topics in calculus. Although the selection was made solely on grades the position of these classes to the extreme right indicates again how high grades are accompanied by high mathematics aptitude scores.

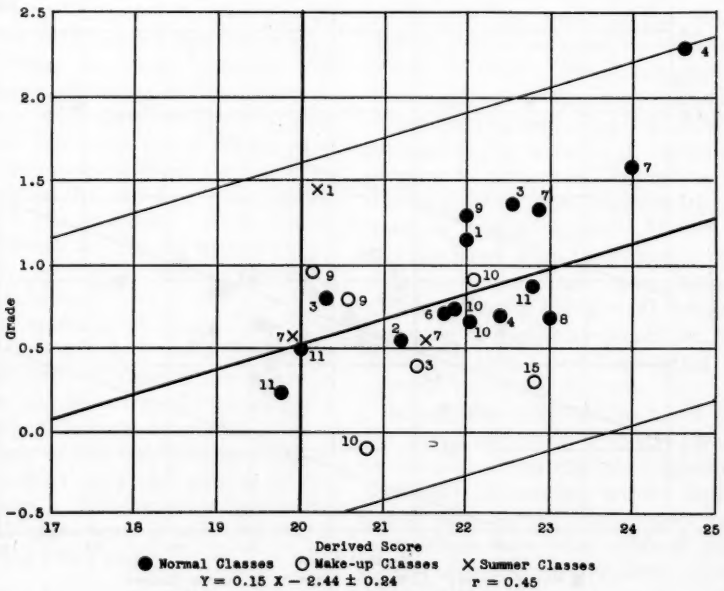

FIG. 5. Calculus II grades with mathematics aptitude scores.

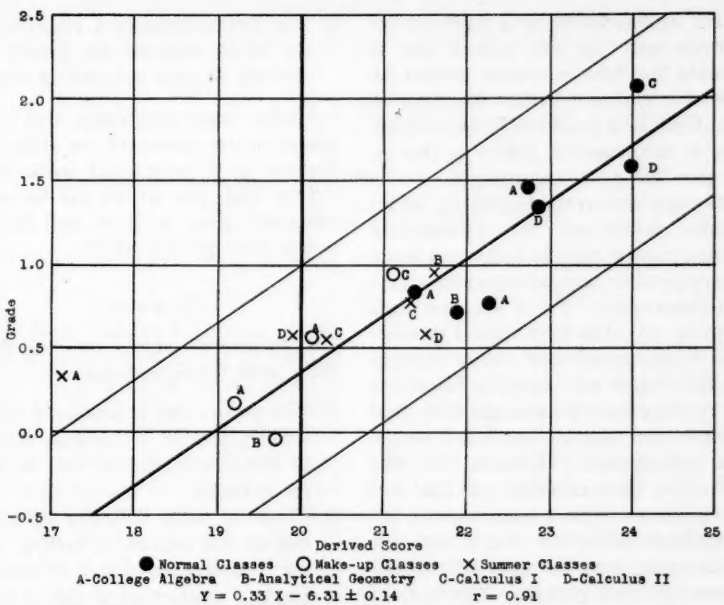

FIG. 6. Mathematics grades with mathematics aptitude scores (Instructor 7).

Several conclusions can be drawn from these two figures.

1. In both figures there is a decided shift of the scatter diagrams to the right in comparison with the scatter diagrams of the freshman mathematics courses. This shows an overall increase in average mathematics aptitude scores in the sophomore year.
2. There is a region to the left in both figures where there are now no normal, make-up, or summer school classes. Evidently, more students with low mathematical ability have dropped.
3. The make-up classes have now caught up with the normal classes and are almost as good as they are.
4. Correlation coefficients are fairly high, which is quite remarkable in that they indicate that a simple one hour test still has predictive value two years after it had been taken.

Figure 6 is the result of an experiment to see what would happen if, instead of comparing classes in one subject using many instructors, classes in several related subjects were compared using one instructor. It answers the question, could a mathematics aptitude test predict average class grades for a single instructor for all of his courses in mathematics in the freshman and sophomore years? To do so, of course, the instructor must be a consistent grader. Several instructors had this reputation among their colleagues but only one, No. 7, had taught a sufficient number of classes in all four subjects to make the experiment worth while.

The high correlation coefficient of 0.91 in figure 6 shows that it is possible for an instructor to be a consistent

grader as measured by a mathematics aptitude test. In this case it also is possible for him to know before he meets his classes whether the class he is to teach is a good, medium, or poor class in mathematical ability so that he can plan his work accordingly.

As suggested in the beginning, under certain conditions the comparison method used in figures 1 through 5 can be employed to recognize good teachers in a department. There are two ways of doing so. The first way is to compare the distances that classes of various instructors are above or below the line of regression for average class final examination scores against average class test scores. However, for this method to be successful, the final examination must be a common one for all students taking the course, and this examination must be scored by a disinterested third person. The test, of course, must be one which measures to some extent the ability of a student to do successful work in the course.

The second way to recognize good teachers is determined by the students themselves and depends on the fact that good students, if given the opportunity, will select the better teachers even though such teachers maintain high standards, whereas poor students are apt to select the poorer teachers, particularly if they have low standards. This method is a variation of the nomination method which was used by the Navy in World War II to rate combat flyers.

The following conditions have to be fulfilled in applying the second method:

1. An instructor must be in the institution long enough for the students to estimate his ability. It is a well known fact that poor students have a tendency to select new instructors.
2. Students must be able to select their instructors freely.
3. The course must be a vital one, one on which depends the ability of a student to pass succeeding courses.

Under these conditions, if a test is known which measures the ability of a student to do successful work in the course, high test scores will be associated with good teachers and low test scores with poor teachers.

Summary

Conclusions which can be drawn from these six figures are:

1. If a proper test is chosen, it is possible to predict in advance the kind of class an instructor will be called on to teach.
2. Students have difficulty in mathematics, not because of lack of training, but because of lack of ability.
3. Lack of mathematical ability is certainly a reason, if not the main one, why students drop out of engineering schools.
4. It is possible to obtain statistical evidence on how closely an instructor grades with respect to his colleagues and whether he is a consistent grader.
5. The reason certain types of classes are more difficult to teach than others is that students in those classes have lower mathematical ability than average.
6. More attention should be paid to the load which students with low mathematical ability try to carry.
7. More instruction should be given to graduate students as to the standards they are expected to uphold. This is only fair to the students whom they teach.
8. Under proper conditions teaching efficiency can be measured by the comparison method or the nomination method.

The Operation of the New England Section, A.S.E.E.*

By CARLTON E. TUCKER

Professor of Electrical Engineering, Massachusetts Institute of Technology

The New England Section of the A.S.E.E. was organized at a meeting held at the Worcester Polytechnic Institute, March 12, 1921. This was apparently soon after sections were authorized in 1920. Since we just spent yesterday morning reading most of our new Constitution, I plan to read that of the New England Section to you in its entirety.

"Committee reports that the officers of the New England Section shall be a chairman and a secretary. These officers shall be elected at the first meeting held in any calendar year and shall serve until their successors are elected.

"These officers shall have entire control of the number and place of meetings and of the program."

This was written by C. Frank Allen, now Professor Emeritus of Civil Engineering of the Massachusetts Institute of Technology. Professor Allen was the eleventh president of the Society, now the oldest living past president, and was secretary pro tem for the special Committee for Division E, Engineering Education, of the World's Engineering Congress in Chicago in 1893, and had a hand in writing the original constitution of the Society.

Dean Gardner C. Anthony of Tufts was elected the first chairman and Dean (later President) Harold S. Boardman of Maine was elected secretary.

For the first eight years of its existence, the New England Section held two one-day meetings each year. For the next six years, one meeting was held every year until the members of the Section had had an opportunity to visit almost all of the engineering schools in New England. Since this time the single meeting plan has been continued each year, except 1945, when transportation rules of the O.D.T. made such planning seem to be unfeasible.

The early arrangement was to have registration first with inspection of the laboratories and campus of the host institution in the morning, a luncheon as guests of the host at noon, followed by a general meeting in the afternoon with two or three speakers and general discussion. Often a dinner meeting was arranged for the evening with speaker from the faculty of the host institution on some topic of local interest. This arrangement worked well, since the atendance did not exceed 100 at any time except once during the first ten years.

In 1934, a plan was adopted which arranged to utilize group conferences by fields of instruction, somewhat fol-

* Presented at the Conference on Sections and Branches, S.P.E.E. meeting, St. Louis, June 20–23, 1946.

lowing the present general plan of the national society, with three conferences in the morning and a general meeting in the afternoon. This apparently appealed to the members, since the attendance at this meeting was nearly double previous averages. The following year, when six or seven conferences were held during the morning, the attendance was about triple. This practice has continued with six to eight conferences at the morning session of each meeting.

At about this time when the Section was expanding quite rapidly, the chairman, at that time, Dean (now President) Carl S. Ell of Northeastern University, suggested the idea of a Program Committee to plan the yearly meetings. This plan has been continued ever since, the Program Committees being appointed by the chairman and secretary, who select one active member from each Institution in the Section and usually a member from industry. The Program Committee meets usually in December or January and again in April to formulate plans for the forthcoming fall meeting. The Committee decides in which fields of instruction it is desirable to hold conferences and also appoints conference chairmen from its own membership or delegates one of its number to secure appropriate persons to be conference leaders. The membership of the Program Committee is changed often so as to work in more new ideas. It is our endeavor to use a different man as conference chairman each year, though occasionally it has been necessary to use the same man a second time in some of the smaller fields. That this method had resulted in increased interest and attendance is evident from the fact that in the days of general meetings, the average attendance was 85, while since the inauguration of the group conferences, the attendance has increased to 275, representing an increase of 223 per cent. Some of the increase is doubtless because of general membership gain, which was 100 per cent during this same period. It should be concluded, however, that these departmental conferences resulted in a stimulated attendance at the Section meetings, probably because of the fact that in general, teachers like to gather in smaller groups and keep to the discussion of their own problems rather than to attend a large meeting and listen to speakers. In the large group, discussion, while in theory permitted, is not practiced anywhere near as extensively.

The average attendance at conferences during the past ten years has been as follows:

Chemical Engineering	20
Civil Engineering	29
Drawing	33
Economics	10
Electrical Engineering	50
Engineering School Libraries	14
English	25
Mathematics	23
Math. and Physics	53
Mechanical Engineering	40
Mechanics	45

It has been our recent practice to have a brief business meeting at the luncheon. This is usually followed by the campus inspection with an afternoon meeting starting at 3:00 or 3:30 with two speakers on topics of general interest. There is usually a dinner meeting with a speaker provided by the host institution and possibly telling something of some features of its research program, or something of general interest of activities of the locality.

At the present time it is common for fifty or seventy-five ladies to attend the

Section meetings. They are usually entertained by campus inspections and short trips to points of local interest, but join with the men at the dinner meeting.

The problem of financing the Section is one which causes the Secretary a considerable headache. In the days when the cost of food was not a major problem it was our practice to add ten or fifteen cents to the price charged for the dinner. The amount received then paid for the necessary cost of printing of programs, postage, and other expenses which for our Section do not exceed fifty to sixty dollars a year. It will be remembered that in one year members had the option of paying the $5.00 before January first and allocating fifty cents to the Section. This brought into the New England Section enough revenue for nearly two years of operation. At present we ask for a contribution of fifty cents per member from those attending the fall meeting, but this does not produce quite enough revenue. However, we are trying this for one more year. It is our feeling that a small contribution from the National Society of 15 cents per member would be adequate to finance the expense of operating the Section. The new constitution prohibits this, however.

For a number of years it has been the practice of the Section to issue a News Bulletin giving the changes in personnel, new buildings and laboratories at the various institutions in the Section. We also publish up-to-the-minute registration figures as of the beginning of the fall term, and since the New England Section usually holds its meeting in the fall, these figures come out within a week or two of the opening of the academic year. The News Bulletin is looked forward to by the membership and provides a means for it to keep abreast of happenings at other engineering schools in the New England Section.

The organization of the section is very informal. Holding the meeting in the fall when the foliage is at its height doubtless helps to stimulate attendance. Football games, however, sometimes draw away some from the meeting. The present section membership is about 450.

Perhaps it might be mutually helpful if the secretary of each section would put all the others on his mailing list for program announcements. I offer this as a suggestion which we in the New England Section will start this fall.

A Five Year Curriculum in Industrial Engineering*

By PAUL N. LEHOCZKY

Chairman of Industrial Engineering, The Ohio State University

The College of Engineering at The Ohio State University has redesigned its courses of study and has changed the length of each curriculum from the orthodox four to a new five-year term. The effective date of the change was October 1, 1945, and all freshmen who entered, or who will enter, on or after that date are registered under the five-year requirement.

It is not the purpose of this paper to discuss the reasons for the adoption of the five-year plan, or to give the details of the problems which arose and which were debated at length, or to deal with the many administrative problems which had to be met when the shift occurred. We do, however, want to sketch very briefly, the several steps taken and the major decisions which had to be made in the College as a whole before we discuss the details of the curriculum in Industrial Engineering.

The faculty of the College of Engineering had, from time to time, discussed and considered a series of related questions which inevitably led to the examination of the curricula or certain of their details. Nor were we alone in this, for engineering educators have debated such problems for decades past and a review of them would be more or less in the nature of a post-mortem and will not be pursued here. Typical questions were: what should be done about the 65 per cent of the entering engineering freshmen who fail to graduate; what does Industry expect of the graduate and of the college; what emphasis should be placed upon science, technology, social studies, and other branches of learning. The discussions by our faculty frequently led to the formation of committees to study the matter but concrete results were seldom attained. Such a committee was appointed by Dean Charles E. MacQuigg on August 18, 1944, and was asked to "consider organic changes in the aims and scope of our teaching objectives."

As the Committee surveyed its problem, it found that a series of factors had appeared which were not present in the field on preceding occasions. First, the War had brought about a keen appreciation of the importance of the basic sciences and of engineering in general. As a result, the all-prevailing principle (accentuated by the Depression) of keeping the "cost per student" low, was relegated to a secondary place and the importance of "preparing" engineers in the full professional sense of the word became of primary importance. Second, the Society's Hammond Committee on "Engineering Education After the War" issued its report in May of 1944 and this report again emphasized the definite need for a

* Presented at the Conference on Industrial Engineering, S.P.E.E. meeting, St. Louis, June 20–23, 1946.

careful analysis and revision of the curricula. Third, it was common knowledge that schools would eventually be crowded with returned veterans and that these would want to have and could afford "the best" education, all factors considered. Fourth, it was felt that the trend in education, in mass education, was toward a longer period of schooling as evidenced by the increase in the average number of years of schooling in the United States during the past hundred years and that a major catastrophy, such as World War II, would act as a catalyzer in accelerating the trend.

The presence of these factors, coupled with the attitude of the administration, gave the Committee the confidence needed to prepare its report and to fight its way through the normal obstacles which had defeated other committees before it. It soon became obvious that extensive surveys, lengthy philosophical discussions and other so-called "basic" work would have to be dispensed with and that we would have to accept the conclusions drawn by other groups as the basis for action. Thus it came about that although the majority of the committee, as well as of the faculty, believed in the expansion to the five-year arrangement, the move was based upon the principles of the Hammond Report rather than upon the results of the deliberations of the Committee.

In its final form, the plan set up a "pattern" which was to be adhered to by all curricula. The pattern divided itself into four parts: 1. Fundamentals including the pure sciences, drawing, and University requirements. 2. The "Humanistic-Social" courses or what we termed as being "broadening" courses. 3. "Departmental," that is, courses required by the curriculum in question. 4. Graduate work where applicable.

(1) Fundamentals were rigidly defined. Some are University requirements such as physical education, military science, hygiene; others are college requirements such as freshman survey. Each curriculum was made to include 30 quarter-hours of mathematics, 12 of chemistry, 12 of engineering drawing, 15 of physics and 10 of mechanics. Further, each curriculum included an additional five hours in either mathematics, chemistry or physics. Industrial engineering finally chose physics although it may wish to switch to probability. Those who wanted more work along "fundamental" lines included additional work under the "Departmental" heading. The curricula of the mineral industries, for example, require a considerable number of courses in chemistry in addition to the 12 plus optional 5 quarter hours. The industrial engineering curriculum calls for additional courses in mechanics (dynamics) and in engineering drawing.

(2) The "broadening" category included 12 hours of English, 27 hours of defined subjects and 15 hours of elective subjects. All subjects, however, whether defined or elective, were carefully examined in terms of the definitions set forth by the Hammond Committee under the six objectives of the Humanistic-Social division. Thus, although accounting was considered to be "broadening" in some curricula, it was distinctly "departmental," that is, technical, in the industrial engineering curriculum. Courses such as economics, economic geography, social administration, political science, psychology, speech, history and so forth, were ruled to be "broadening." In the case of the 15 elective hours of "broadening" work, the student may choose from the offer-

ings of certain entire departments of instruction including, for example, music, fine arts, philosophy, political science, economics, psychology, botany, and many other specified departments.

(3) All degree granting departments were given complete freedom in their choice and make-up of the "Departmental" category and in many cases practically the entire "technical" offerings of the old four-year curriculum were carried over into the five-year curriculum with but minor changes and most of those confined to changes in sequence, numbering or general arrangement of the old courses. There were certain major changes in the industrial engineering curriculum to be discussed at a later point.

(4) The fourth major consideration concerns itself with graduate work. Students who show promise of being able to do work of graduate caliber are permitted to become candidates for two degrees, both awarded at the end of the fifth year. Tangible requirements included a minimum general point-hour ratio of 2.5 and a minimum ratio of 2.75 in the major, all by the end of the third year. Intangible requirements include research interest and other capacities required of graduate students. Acceptable candidates are screened carefully during their fourth year and are registered in the Graduate School during the fifth year with graduate credit for certain courses retroactive to the fourth year. The dual registra-

FIVE YEAR CURRICULUM IN INDUSTRIAL ENGINEERING
AT
THE OHIO STATE UNIVERSITY

AUTUMN QUARTER		WINTER QUARTER		SPRING QUARTER	
First Year					
Mathematics (421) Algebra	5	Mathematics (422) Trigonometry	5	Mathematics (423) Analytic Geometry	5
Chemistry (416) General Chem.	4	Chemistry (417) General Chem.	4	Chemistry (419) General Chem.	4
English (410)	3	English (411)	3	English (412)	3
Engg. Drg. (401)	4	Engg. Drawing (40) Descriptive Geom.	4	Engg. Drawing (40)	4
Survey of Engg. Principles	1	Survey of Engg.	1	Hygiene	1
Military Science	2	Military Science	2	Military Science	2
Physical Edu.	1	Physical Edu.	1	Physical Edu.	1
Total	20	Total	20	Total	20
Second Year					
Mathematics (441) Calculus	5	Mathematics (442) Calculus	5	Mathematics (443) Calculus	5
Physics (429)	5	Physics (430)	5	Physics (432)	5
Ind. Engg. (419) Machine Shop	3	Ind. Engg. (421) Adv. Mach. Shop	3	Ind. Engg. (405) Foundry Practice	3
Economics (403) Principles	3	Economics (404) Principles	3	Ind. Engg. (418) Weldg., Heat Treating	3
Military Science	2	Military Science	2	Military Science	2
Total	18	Total	18	Total	18
Third Year					
Physics (433)	5	Mechanics (602) Strength of Materials	5	Mechanics Option Dynamics or others	3
Mechanics (601) Statics	5	Accounting (405) Principles	5	Accounting (624) Factory Costs	5
Engg. Drawing (421) Machine Drawing	3	Ind. Engg. (601) Management of Men	4	Mech. Engg. (627) Materials	5
Ind. Engg. (661) Prod. Control Charts	3	Political Science (599) Poli. Science	3	Psychology (501) Ind. Psych.	3
Social Adm. (6xx) Probs. in Soc. Adm.	3			Economics (641) Labor Problems	3
Total	19	Total	17	Total	19

SUMMER BETWEEN THIRD AND FOURTH YEARS

Ind. Engg. (439) 6
Practical Experience in an Industrial Organization

AUTUMN QUARTER		WINTER QUARTER		SPRING QUARTER	
Fourth Year					
Ind. Engg. (603) Time and Motion Study	5	Ind. Engg. (604) Time and Motion Study Lab.	4	Ind. Engg. (710) Laws of Management	3
Ind. Engg. (761) Prod. Control	3	Ind. Engg. (762) Adv. Prod. Control	3	Ind. Engg. (751) Tool Engineering	3
Mech. Engg. (737) Machine Design	4	Mech. Engg. (738–39) Machine Design	5	Ind. Engg. (771) Safety Engineering	3
Electrical Engg. (642) Electrical Engg.	4	Electrical Engg. (643) Electrical Engg.	4	Electrical Engg. (644) Electronic Controls	4
English (519) Reports	3	Business Org. (640) Corp. Org. and Control	3	Geography (6xx) Economic Geography	3
				Ind. Engg. (630) Inspection Trip	2
Total	19	Total	19	Total	18

SUMMER BETWEEN FOURTH AND FIFTH YEARS

Ind. Engg. (639) 6
Practical Experience in Industrial Engg.

Fifth Year—Candidates for B.I.E. degree					
Dean's Course	0	Dean's Course	0	Dean's Course	1
Ind. Engg. (708) Plant Design	5	Ind. Engg. (709) Prod. Engg.	5	Ind. Engg. (799)	6
Ind. Engg. (599) Conference Course	1	Ind. Engg. (599) Conference Course	1	Ind. Engg. (599) Conference Course	1
Technical Electives	6	Technical Electives	6	Technical Electives	5
Non-Technical Electives	5	Non-Technical Electives	5	Non-Technical Electives	5
				Ind. Engg. (730) Insp. Trip	2
Total	17	Total	17	Total	20
Fifth Year—Graduate School group. Candidates for degrees B.I.E. and M.Sc.					
Dean's Course	0	Dean's Course	0	Dean's Course	1
Ind. Engg. (801) Graduate Seminar	1	Ind. Engg. (802) Graduate Seminar	1	Ind. Engg. (803) Graduate Seminar	1
Ind. Engg. (708) Plant Design	5	Ind. Engg. (709) Prod. Engg.	5	Non-Technical Electives	5
Non-Technical Electives	5	Non-Technical Electives	5	Graduate Courses and M.Sc. Thesis (8xx)	11
Graduate Courses (I.E. 8xx)	6	Graduate Courses (I.E. 8xx)	6	Ind. Engg. (730) Insp. Trip	2
Total	17	Total	17	Total	20

tion in the fifth year does not, in the case of industrial engineering, interfere with the Engineering College program because a large part of this year is made up of technical electives and the chief objective of the course arrangements is to individualize programs in any event.

With this rather sketchy introduction, let us examine the curriculum. The tabulation which follows gives the department and/or course name, the course number and the number of credit hours per quarter. (Three quarter hours equal two semester hours.)

The curriculum may best be described in terms of a column. This column is based upon the five fundamental "languages" used by all engineers: Mathematics, physics, chemistry, engineering drawing, and English.

Next are the secondary, but still general (from the point of view of engineering) courses which lead up to the field of specialization. These are: the shop courses (heat treating, welding, foundry, and machine shop), mechanics (statics, strength of materials and dynamics), electrical engineering principles including electronic controls,

properties of materials, machine design and others. Others branches of engineering (mechanical, aeronautical, welding, electrical) also utilize these courses although the emphasis as to quantity, quality and detail varies, of course.

Based upon these two categories, the basic sciences and the basic applied sciences, is the relatively narrow column of the industrial engineering courses proper. Some of the courses in this group are taught outside the department. For example, accounting and factory cost accounting are taught by the Accounting Department of the College of Commerce; industrial psychology is taught by the Department of Psychology of the College of Education; economics and labor problems are taught by the Department of Economics. The specific courses taught within the Department of Industrial Engineering are grouped into five areas as follows:

Area 1. *General Management and Personnel.* Courses in this category include: I.E. 601 Management of Men; I.E. 710 Laws of Engineering Management; I.E. 661 Production Control Charts; and several conference and research courses on the undergraduate and the graduate levels.

Area 2. *Engineering Economy.* This area includes courses normally covered under the heading of Engineering Economy. We have an elementary course I.E. 761, an advanced course I.E. 762 and a series of research courses on the graduate levels.

Area 3. *Methods Engineering.* This area includes courses normally covered under the heading of Time and Motion Study. Courses in this category include I.E. 603 Time and Motion Study, I.E. 604 Time and Motion Study Laboratory, and several research courses.

Area 4. *Production Engineering.* This area is broken down into three zones: (*a*) *Tool Engineering* which involves the fundamentals of tooling up for production; the design of jigs, fixtures, gages; technical problems of tolerances, limits, interchangeability and machine selection.

(*b*) *Plant Design and Equipment* involving technical problems of space requirements, equipment requirements, selection of tools, flow of product, synchronization, long range planning, materials handling systems, external and internal layout.

(*c*) *Production Engineering* involves the redesign of the product from the functional to the production stage. Redesign for production: stampings, castings, weldments, extrusions. Quality requirements and their control. Redesign to suit equipment available.

Here, as elsewhere, there are additional research courses on the undergraduate and the graduate levels.

Area 5. *Safety Engineering.* This area, at present, consists of one lecture course in Safety Engineering (771) and of a series of research courses on the undergraduate and graduate levels.

The Department of Industrial Engineering, from the administrative point of view, is made up of three units: the Shops unit, the Welding Engineering unit and the Industrial Engineering unit. Since research work and graduate work are now of the same importance with the teaching of standard courses in the 5-year set-up, the Industrial Engineering unit of the Department has been completely reorganized, new personnel engaged and a specialist put in charge of each of the areas enumerated. The professor in charge of any area teaches the basic

undergraduate courses of his area (a duty which consumes from ⅓ to ½ of his time), teaches the applicable graduate courses and conducts all research work in his area as well. Although the Shop unit (machine, welding, heat treating, forging, foundry) acts as a service unit to the College, even other colleges, its position within the Department enables us to integrate our shop courses with the courses in industrial engineering. For example: the emphasis in the machine shop courses is not upon the acquiring of skills but upon principles of mass production, problems of tolerances, limits, machine capacities, and so forth, as they are illustrated in the operation of the equipment.

The 5-year plan, as it now exists, is of course in its initial form and will undergo many changes before it reaches a stable equilibrium. We may want to make shifts in mathematics, mechanics and physics in the "Fundamentals" area. We will make changes in our "Departmental" area involving courses in costs, in quality control, and others. We undoubtedly will want to make many changes in our "Broadening" area; the only criterion used so far in setting up courses in this area has been whether or not the course was "broadening" as defined by the Hammond Committee. Whether or not there is a coherent sequence of broadening courses, what this sequence should be, what courses are most desirable, etc., etc., all remain for future study. The most important obstacle, finding space for them in the curriculum, has been overcome.

We were, of course, very much interested in the reactions of the students, of the alumni, of industry and of the public, to our shift from four to five years. We found that the main body of the groups enumerated above, has no opinion. But those who do have an opinion are overwhelmingly in favor of the change, are in many instances enthusiastic about it. The criticism we've met with, so far, has dealt with the lack of special courses such as courses dealing with rubber technology, internal combustion engines, and others. Or there is alarm expressed over the lack of emphasis or over-emphasis on some phase or another of the curriculum. However, this was expected. Our biggest problem just now is the handling of the tremendous student load.

Meeting the Engineering Needs of Agriculture*

By ARTHUR W. TURNER

Assistant Chief in Charge of Agricultural Engineering Research, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture

Many world students hold that the foremost interest of every family in the world is food, followed by clothing and shelter. These are the essentials of all life. Perhaps at no other time in history has it been more clear that the absence of these basic requirements is likely to result in chaos in the political and economic life of the world's people.

The hungry man with a hungry family is not likely to be concerned with the problems of his own government, let alone with world federations or the philosophies of governments. He will follow any leader as long as he is promised food. History is full of examples of this truism. The war just ended, so some students contend, was a tragic demonstration of it. The peoples of the Axis nations followed false leaders partly because they were hungry and lacked other essentials.

Is the world today witnessing a similar situation? What is basically the cause of the present unrest? Leaders in nations the world over say it is essentially the lack of food. It is the same basic situation that has been the cause of all major disturbances in our so-called peaceful civilization.

Wheeler McMillen, Editor of the *Farm Journal,* said recently: "Poverty, the lack of food and goods, may not be the only cause of war. I will venture, however, as a reasonable hypothesis well worth the most vigorous efforts to explode, that a substantial increase in food production in all lands will guarantee peace more firmly and for longer than any other course that will be proposed."

McMillen is not alone in that thought. The papers and magazines are full of similar statements with suggestions to alleviate the situation, both for the present new emergency and for the sake of a long-range program for peace among nations. Recently, Herbert Hoover, the outstanding engineer that he is, reporting the findings of his world tour to survey the food situation, made this statement:

The Yardstick of Hunger

"Calories are the yardstick of hunger, of starvation, of famine, and finally death. . . . As we descend the scale from the stage of hunger, to the stage of disease and epidemics, to the stage of public disorder, to the stage of starvation of all but the strongest, we come finally to the stage of mass starvation at less than 900 calories a day. . . . Long before a population is reduced to these lower levels, however, government would break down. We must prevent the descent to these lower levels. Reconstruction and peace in the world would go up in the flames of chaos if we were to fail."

* Presented at the Conference on Agricultural Engineering, S.P.E.E., St. Louis meeting, June 20–23, 1946.

The importance of food as a stabilizing influence in the world was recognized by the formation of the Food and Agriculture Organization and ratification of its constitution by 42 nations at Quebec, Ontario, last October 16 as a vital part of the U.N.O. Apropos of the importance of food in world peace, Sir John Orr, director general of F.A.O., made this statement only a month ago at the first plenary session of the organization at Washington, D. C., devoted to urgent food problems:

"The cooperation of government in a common effort to free the world from hunger will do more for an enduring peace than the delineation of political boundaries and the drawing up of political peace treaties, essential though these may be. Famine is the greatest politician of all. Peace cannot be built on *a foundation* of empty stomachs."

World Needs Aid of Agricultural Engineers

The position of our agricultural engineering divisions in the Nation's Capital and in the Agricultural Research Administration of the U. S. Department of Agriculture is most interesting, and also strategic, with respect to service they can perform not only for farmers of the United States but also for the agriculture of other countries in helping to bring about the needed increases in production. Delegations from many—and possibly a majority—of the nations of the world, have consulted our group of agricultural engineers on how to introduce and accelerate engineering in the agriculture of their respective countries to increase food production.

In every case, the story has been the same. The agricultural leaders of foreign countries have wanted to know (1) how to increase food production per worker, (2) what they might do to substitute machines for hand methods, (3) how to conserve their soils while at the same time increasing production, (4) how to store commodities safely for long periods to alleviate suffering during times of drought and famine, and (5) how to provide a better living for their people from the land and other resources available to them.

All those are engineering problems that have to do with facilities, methods, and labor. The first two go hand in hand, for increasing production per worker in agriculture must follow the same pattern as in industry—by the replacement of hand methods with machines. Surely, conservation of soils, both in quantity and quality, has engineering problems with their relation to plant growth, root characteristics, soil structure, and the resulting action of both with respect to water activity. Storing commodities involves engineering structures which may provide the proper environmental requirements. Obviously, the production of more food per worker also must involve engineering methods that will not only increase the amount of products obtained from each particular area or region, but which also will increase farmers' incomes and enable them to provide more food of better quality for the rest of the population.

Hunger and starvation are not new in the world. It has been ever thus. The Four Horsemen of the Apocalypse have stalked across the land following every war—and the foremost of these is hunger. The earliest recordings of man, nearly 4,000 years before Christ, tell of famines. The Bible states that Esau sold his birthright for a mess of porridge. Esau was not hungry—he was famished. And so it is today.

Man has taken hunger for granted. Only America—the United States, in fact—has been spared famine, and our record is not perfect in this respect.

Engineering advancements in agriculture have been important factors in enabling this country to avoid food shortages as critical as those which other countries have sometimes faced. Starting with a few farm machine inventions a century ago, America has made tremendous commercial and scientific advancements. I list only a few: 1831, the Manning Mower and the McCormick Reaper; 1833–37, steel plows by John Lane and John Deere; 1837, Pitts' Threshing Machine.

As a result of these and the many other machines that have followed after them, in 1944 and 1945 a rural population of less than 25 million people established an all-time record in producing more food and clothing material than has been produced in any other similar period of the world's history. Now, in 1946 and 1947, for the sake of worldwide humanity, farmers are asked to exceed their previous production records. Here is what is involved in such an undertaking:

1. Retention of the top soil—the very life blood of the world.
2. Field crop production equipment, from that needed in seedbed preparation, including proper fertilizer placement, to harvesting.
3. Controlling and providing through irrigation, proper moisture for crops, orchards, and pastures.
4. Farm storage facilities so commodities can be stored safely either for farm feeding or year-round marketing at the growers' convenience rather than having to sell on a flooded harvest market.
5. Transportation of farm commodities from producer to consumer with minimum loss in quantity and quality.
6. Shelter for farm animals to maintain their health, increase production, and conserve the farmer's chore time.
7. Adequate farm housing in which are combined the farmer's living, farm business headquarters, and food-processing operations.
8. Controlling plant and animal pests and diseases for maximum production.
9. Partial processing of farm commodities so portions with commercial value *only* are transported from the farm to market.
10. Application of electrical energy either as power, light, or heat for farm efficiency, health, and sanitation.

In all these phases of farming there are engineering applications.

Our Country's Largest Industry

Agriculture is the largest industry in America. Let's look at it with respect to the three engineering factors—power, labor, and materials.

Prior to the war, 50 million horsepower were available to all manufacturing. Agriculture had 97 million horsepower.

The 1940 census reported 18.45 per cent of all persons gainfully employed to be in agriculture as compared to 24.3 per cent in all manufacturing. Even during the war, 15 per cent of the gainfully employed were in agriculture. By way of comparison, if I may be allowed to refer to agricultural labor in other countries for a moment, in China

and India 88 per cent of the population is employed in agriculture, indicating the predominance of hand labor in those countries as compared to our own use of machines.

In materials, agriculture in this country purchases one-third of a billion dollars worth of building materials annually, more than three-fourths billion dollars worth of machinery and equipment, and over a half billion dollars worth of commercial fertilizer. The present and immediate potential consumption of electricity by agriculture is enormous. Right now high lines provide power for more than three million separate farm industries. Surely, agriculture is big business and has its numerous engineering problems.

Engineering has done much for transportation, commerce, and industry in its several phases and applications. It was a major factor in winning the war. Engineering can do as much for agriculture as it has for other phases of our modern life. It is paradoxical, however, that engineering for the farm has been long delayed. Agriculture was our original industry and still is our basic industry.

Engineers of Food Production

In every other undertaking, whether in industry, commerce, transportation, communications or construction, the job is first engineered to see if it is feasible. After that, it is engineered to assure success of the project.

In agriculture, the procedure has been different. Many of us grew up in agriculture and either accepted it as it was, or, thinking it a life of drudgery, forsook it for a more convenient profession or one that appeared newer and offered greater challenge. Now, however, the world is looking to engineers to apply to agriculture, in all nations, the same skills that have been used in the other industries. Improved transportation and communication have made "One World." People in every part of the world are acquainted with or at least informed as to how the people in other parts of the world live.

Agricultural engineers like to refer to themselves as engineers of food production. Here then is the challenge now facing those in this profession. Unless engineering techniques can be applied in the agriculture of other nations as it has in the United States to raise the standards of living of all peoples, our own advancements and wealth can become a threat to the peace of this country and to that of the world.

Background and Training Needed

What background and training should a food-production engineer have? First, he must be an engineer because he deals with power, labor, and materials. He must also know farming and the problems of crops and livestock production, processing, and marketing. The answer to the background and training needed by the agricultural engineer is indicated by the fact that 85 per cent of all agricultural research has engineering implications. This is true whether the research be in farm animal improvement, commodity development, farm management, home economics, farm product utilization, soil conservation, pest control, or almost any other field of farm science.

Let's consider the general picture of labor use on the farm today. All know what is happening to labor costs outside of agriculture and also to the world-wide demand for more food. Such increases in costs cannot be met by agriculture unless labor require-

ments are reduced materially, as the farmer cannot work on an 8-hour day and a 40-hour week.

Considerable progress has been made in reducing labor so far as field crops are concerned by using machinery and power. An acre of corn, our largest crop in the United States, can be produced with as little as 3.6 man-hours as against 15 man-hours in 1900. In other special studies, 2.77 man-hours were required to produce an acre of oats and 4 hours for an acre of soybeans.

"In contract to this efficiency in field work," states Professor Deane G. Carter of the Agricultural Engineering Department, University of Illinois, "these same farmers require 6.75 hours to bring a hog to market weight, 80 hours to care for one cow a year and 262 hours to handle the farm poultry flock of 125 hens."

Suppose, to be more specific, it becomes possible to undertake mechanization of the cotton crop from planting to harvesting. That is an engineering job. In addition to engineering fundamentals, however, the agricultural engineer must know agricultural fundamentals. He will need to have a knowledge of soil tilth with regard to respective kinds of soils, climate, and crops. One might refer to this as soil physics. Other questions that will plague the engineer on this problem are when, where, and in what quantities to place fertilizers, the nature of and frequency of cultivation to control weeds and to stimulate maximum production. What are the possibilities of using chemicals, heat, and electric energy in seed treatment in the various field operations.

The applied mechanics for field machines are interesting. We do not have the solid foundation of the power generating plant, the steel rails of trains, or concrete ribbons of motor vehicles. Instead farm machines operate over uneven terrain. Power is transmitted through angles by sprocket, shaft, belt and chain and these angles change while the machine is in operation, either to meet terrain irregularities or crop requirements.

The agricultural engineer should work with the plant breeders. The engineer knows the characteristics he desires in seeds or seedpieces for planting, and such characteristics as the type of straw or stalks desirable for uniform machine harvesting. The engineer does not require 6- to 8-foot corn for harvesting; in fact, he would like to harvest all field crops with one universal machine, but this is impossible with crops in their present physical makeup. However, a special harvesting machine for each of several crops on one farm may not be considered good economics.

Engineer Needs Wide Knowledge

The agricultural engineer needs a knowledge of many things. Some field harvesting is now delayed because the commodity is too moist for safe storage. What conditions are necessary in storing various crops and what are the fundamental factors in transferring moisture from the center of a kernel or seed to the surface where it can be evaporated or removed? In other words, what are the heat transfer characteristics of the farm commodities?

What kind of cotton characteristics are required for successful mechanical picking and vice versa? Mention might be made also of the hay crop which, to my way of thinking, is handled very awkwardly and wastefully. It is a 2 billion dollar farm value commodity and grown in every state. Engineers need to study this crop more closely

not alone from the engineering standpoint, but also as to its ultimate uses and feeding value and how to preserve these values. Engineers also need to study the other small grains, sugarcane, sugar beets, Irish and sweet potatoes, and the lowly peanut which has now grown to a more than 200 million dollar crop, but is handled with the same methods as when a "side crop." Tung nuts, comparatively new in this country, now pass the 3 million dollar mark value and fruits, cannery vegetables, and tobacco, which is handled 16 times by hand from the picking of individual leaves to baling for the factory, are costly to produce. In connection with all these commodities there are hundreds of engineering problems that will not be solved except through application of engineering techniques.

Insects, yes, 2,500 different ones, are attacking our crops and animals. Last year, our corn crop suffered a 37 million dollar loss due to the corn borer alone. The entomologists develop insecticides and fungicides, both liquid and dust, but have been stymied by methods of application. They rely upon the agricultural engineer for hydro-mechanics, air dynamics, as well as power and power transmission aspects of most control operations—whether by ground application or by the airplane method. Some of the new concentrated insecticides are very effective when applied at the rate of only 1 gallon per acre. To atomize the spray and obtain effective application is an engineering job. There is talk at present of flying tons of insecticides hundreds of miles to control the spruce bud worm and the gypsy moth, which are threatening our timber lands. The use of C-47 and C-54's has been mentioned.

Requirements of Farm Buildings

It is impossible to estimate the loss of harvested grains in storage—why? What are the storage requirements of the many grains anyway? It is a common sight to see all markets flooded at harvest time. The grower does not have storage facilities to retain the commodity; in fact, there are not sufficient facilities, commercially or otherwise, to provide an adequate supply of all foods in good condition in America throughout the year.

What are the problems in animal shelter? At present, 3 pigs out of each litter die shortly after birth. That is more than just 3 dead pigs, because a sow consumes many bushels of grain for each pig up to farrowing time. This loss has been reduced by 30 per cent by improved housing, use of guard rails, and electric brooders.

Is there a comfort zone or range for dairy cattle efficiency— if so, how will the temperature, humidity, light and air movement be maintained in dairy barns in our northern and southern states? These are very important factors in livestock production. They require knowledge of engineering fundamentals and animal characteristics. They are basic for general information on successful and efficient livestock production.

Dean William W. Wurster, of the School of Architecture at Massachusetts Institute of Technology, stated in a conference on Rural Housing held at Boston, Massachusetts, on April 12, that architects in general have little interest in rural housing largely because they do not know farm requirements and cannot undertake the work profitably.

Farm houses alone, average 75 years of age. The house is built on the farm

and must be lived in through the changing requirements of the family and the families. The family cannot just move to another part of the farm or the community. A farm home serves at least four purposes—it is first the home, second, the business headquarters of the farm, third, lodging for the help, and fourth, the processing plant of many farm commodities. The type of farming may change, in fact, often does in just one generation alone. Just how can present buildings be reconverted so that the various types of farming can be conducted efficiently? All those are engineering problem that require a definite knowldege of farming operations.

Agricultural Aspects of Soil Conservation

The very existence of a people is dependent on conserving the soil and water of its agricultural lands. The loss of the top fertile productive soils of many nations of the world is alarming. Lands, thus destroyed, are lost for further food production. Soil losses in our United States are tragic. I have heard farmers in the south central region, when referring to lands in their states that have been abandoned as the result of soil erosion, say, "This has happened in my life time." Think of that—destroying good productive farm lands in one generation.

Conserving and utilizing our agricultural lands; that is, draining excess water, adding needed moisture through irrigation, adapting the land contour to provide soil conservation, and controlling water action to prevent erosion and flood requires basic training in hydraulics and agriculture. Effective programs include a working knowledge of the physics of the various soil types and its relationship to the type and quantity of rainfall, run off in relation to slope, quantities of irrigated water and frequency of application for soil types, climate, and crop, all functioning under the laws of the mechanics of fluids.

Other agricultural implications are root and growing characteristics of vegetative cover crops and trees, and field operations in relation to conservation practices.

Utilizing Electric Energy on the Farm

Electricity is now on the farm. Farmsteads need adequate wiring and numerous income-producing applications. Electricity is an energy that has unlimited possibilities on the farm. It will serve as power, light, and heat. Possibly, this may include heat and radiation to improve animal health and the products. Maybe we can expedite commodity sorting and I am sure reduce time used in different chore jobs which are repeated daily.

"The job of proper rural electrification is not finished when all farmers who wish electric service have it," stated Grover C. Neff, President of the Edison Electric Institute, in New York, on June 5th. "The principal objective is to get electric power efficiently applied to as many farm jobs as possible in ways that are profitable to the farmers."

"In order to do this properly each company needs a number of properly trained men who understand farming and who understand the application of electricity to farm operations."

Agriculture needs engineering—engineering based on a knowledge of Agriculture. George W. Merck, President and Director of Merck and Company, who served as Chairman of the United States Biological Warfare Com-

mittee, in a paper before the George Westinghouse Centennial Forum at Pittsburgh, May 16, talking on "Peacetime Implications of Biological Warfare" stated:

"Every agricultural or horticultural practice which effects growth, development, ripening, or storage can be influenced to economic advantage." And I add, "by the agricultural engineer working with and appreciating the important contributions of the special agricultural scientist."

Agriculture Requires Special Engineering Training

The engineering requirements of agriculture are a combination of engineering fundamentals and agricultural fundamentals. They are not the so-called trades or skills but the basic fundamental requirements of the two professions—one without the other results in lopsided training and subsequently lopsided view points.

The training of the agricultural engineer has the same relationship to agriculture as that of the mining engineer to mining, and the aeronautical engineer to aeronautics. It is an engineering profession serving the agricultural industry. That industry, in many of its phases, calls for the highest type of engineering, a far advancement from its early beginning as farm mechanics. Its true importance stands out in bold relief.

A question of immediate importance is how to acquaint embryo engineers with the importance and opportunities in agricultural engineering. The practicing agricultural engineers—many hundreds of them—are attaining distinctive recognition for their work. This is convincing evidence of constructive service. It seems to me that each agricultural engineer should take the initiative in showing the achievements of his colleagues and his profession. His audience should include the leaders of other engineering professions and the agricultural scientists. Both may look on the agricultural engineer with overemphasis on his field—engineering from the engineer's view point and agriculture from the agriculturist's view point. And obviously each may tend to minimize the importance of the other's field. That cannot be, for it hinders progress in agriculture.

I am glad that deans of both engineering and agriculture are in this meeting. Let me say for the benefit of the agricultural deans that the agricultural engineer's training *must* include the true fundamentals of engineering—and to the engineering deans, the training calls for the fundamentals of agriculture.

We are engineers in every sense of the word, and as such we are entitled to and should be accorded the same consideration and counseling that is given other engineering professions from the Engineers' Council for Professional Development—and engineering licensing agencies in every state.

The engineering needs of agriculture are many. Proper training of the engineer is foremost. However, recognition of the graduate of the agricultural engineering course is essential so that increasing numbers of ambitious young men with proper qualifications, will enroll in the agricultural engineering curricula. In that way we—as members of the great engineering fraternity—will join forces to do an overall engineering job for America and the World.

Trivia from Oblivia

By EDWARD C. ELLIOTT
President Emeritus, Purdue University

I

A few days ago an American newsman broadcasting from London described the British observance of the second anniversary of V–D Day. He referred to the accounts of the events of the day appearing in the London daily papers. His own reactions were dramatically crystallized in the phrase, "Adjectives certainly took a beating today."

What has just been said by the presiding officer is a strong temptation for me to do some "adjective beating" to express the quality of my appreciation for his generous and undeserved presentation. I forego this self-indulgence, for time marches on!

Many times during recent weeks have I wondered whether it was Harry Rogers or I who had suffered a mental lapse when the program for this evening was arranged. Had I, when accepting his graciously tendered presidential commission to be in this high place at this high time, not fallen under the spell of his hypnotic powers, and been rendered incapable of making proper use of my own will? Had he, under stress of program making necessity, surrendered his own judgment to blind chance and circumstance?

Yours will be the verdict. It is easily possible, before the evening is ended, that you will have concluded that both of us—he the benevolent dictator of the affairs of the Society and I, who must now be classed as one of the "tired old men" of the profession of teaching—are guilty of extreme inhumanity to men; and should receive the maximum punishment as postprandial felons. Be this the case, it is certain the records will show that both he and I enjoyed a hearty meal just before being placed in front of the firing squad!

II

When I sought to find out just what was expected of me tonight, your President played a delightful "possum" role. However, his expert hemming and hawing did not conceal his hope that my prescription would include a slight amount of some specific to serve as an antidote for banquet boredom. A high hope, indeed; that together we might be light hearted without becoming light headed.

Experience has proved, when starting on a journey, such as the one ahead of me, that it is prudent to have and to hold in the brain box of travel at least one fresh idea. Sometime and somehow, during the next thirty minutes, the angels being on my side, you may expect to hear of a certain stuff labeled, *Thermo-Humanics*. This stuff is being identified now as partial insurance against the constant risk to which dinner speakers are exposed: that of losing themselves and their belongings in the woods of words. With this foreknowledge, you will be able later on the

more easily to respond to the question: What did he talk about? What he said may be another and more difficult question.

III

The title under which I speak—"Trivia from Oblivia"—may appear to most of you to be a trifling verbal device for torturing you with uncertainty. In truth, the words of the title were cautiously chosen. They are intended to emphasize the unimportance of the thoughts of one who no longer possesses responsibility for his saying and his doing.

That we are in the historic, dynamic city of St. Louis brings to mind a diverting incident. Not long since, Washington University, of this city, inaugurated its new Chancellor—a long established and too frequently repeated indulgence of universities. The ceremony brought to the University a group of the nation's distinguished scientists and engineers. Chancellor Compton, himself being of the highest nobility of the realm of Science, these delegates possessed more than the usual quality of rank and quantity of distinction. Just before the inaugural exercises were to begin, it was found that the loud speaker was out of commission. The noted visitors then started tinkering with the microphone. It is reported that the combined efforts of twenty-six scientists and engineers who had helped to split the atom, could not put the microphone together. Then someone had the wisdom to call a practical electrician. He did the job, and his charge was fifty cents. It may be sheer impertinence for me to confess to the feeling that I am expected to render a service similar to that of the electrician, with this important difference: The electrician got fifty cents.

IV

It is a well known fact that I have been tossed into the scrap pile of the years; and have a present value signified by a zero without a rim. Yet, as long as there is life, there is vanity. Being salvaged for this hour and permitted to stand in the presence of the members of this influential Society for the Promotion of Engineering Education furnishes a measure of excusable self-satisfaction.

Here is assembled the high powers of the profession of engineering. To be sure, your names are not cast in the tablets of bronze, nor cut in the granite cornerstones, marking the great structures and mechanisms that the world associates with the engineer. It is no mere whimsey to state that here is the heart of the engineering profession. What you are doing, and what you are yet to do, with the youth being marshalled for the ranks and the leadership of engineering will determine not only what engineering is to be, but in all likelihood, what civilization is to become.

For a long time it has been an important part of my official responsibilities to know the activities of this Society, and to take account of its continuous efforts for the advancement of the engineering profession. This may be said, without subscribing to the complete truth, of the sentence with which my good friend John Mills introduces his recent book on "The Engineer in Society"—

"Engineers as a class are too modest. Even as individuals, they are rarely boastful of their ability or their accomplishments. They do not advertise themselves or their profession."

Engineers individually may be "modest." I would not say "too modest."

They may not be boastful as individuals. It would seem that they are entitled to be boastful collectively. How otherwise would the world be able to proceed, as it has, from chaos to chaos.

V

Just prior to the signing of the Rogers-Elliott Chatter Charter, under which we are operating, I received a letter from my good friend Fred Kelly, widely known journalist and author of the definitive biographies of the Wright Brothers and of Purdue's man of influence, David Ross. Fred Kelly lives in a country place in northern Ohio, where he was working on the Biography of George Ade. The first chapters of this were long overdue. His letter opened, "I have been so (here several words deleted by the censor) busy these many weeks keeping the labor-saving machinery of this household in working order that I have had neither time nor energy for my proper duties." This, as I read it, reminded me of a similar trenchant comment made several years ago by the editor of one of the nation's great weekly journals. "We are," he said, "entirely too busy to attend to our business."

These chance bits of paradox have furnished me with the catalysts for the processing of the raw materials of my thinking.

VI

In one of the very few of the poems of Archibald MacLeish that I am able to understand are to be found these lines:

"We have learned the answers all the answers
It is the *question* we do not know
We are not wise. We have a way of saying
What is the meaning of Life?
No one has answered us."

I have elected to fulfill my present commission by asking questions. Perhaps there is but one question in different forms. The answers to these questions I do not know. Nevertheless, I have a present conviction that concerted efforts to ask the right questions and to find the right answers represents a critical part of the yet unfinished business of engineering and of engineering education.

What, then is your new business, as engineers, in this darkly clouded world of ours?

VII

The accepted goals of engineering education have long been the technical conditioning of men for a complete understanding of the materials and forces of nature; the qualifying of men to measure these materials and forces with ever increasing precision; and the fitting of men to convert these materials and forces for the beneficent use of mankind. Furthermore as one of your own great leaders has stated, "An engineer differs from the technologist in that he must concern himself with the organizational work and economic aspects, as well as technical aspects, of his work."

In a broad sense, it may be said that through his utilization and application of power for the creation of structures and the mass production of goods, for the speed of transportation, and for the ease of comunication, the engineer has pioneered for the making of the conditions of human living whereunder the age old barriers separating men, and dividing peoples, were steadily broken down. How else may the meaning of the words, distance, drudgery, and disease, be interpreted for modern man?

Unconsciously, engineering has been laying the material foundations for a

one-world structure. Unconsciously, too, engineering has created new menaces to the existence of any world. Here again are the words of authority from engineering:

"We technologists, while admitting both accidental and premeditated harmful effects of science, nevertheless see the gains from technology as far outweighing the losses, and *we have sure faith in the social value of our efforts.*"

One easily recalls the prideful claims of engineers of twenty-five years ago for having brought into existence the mechanical slaves that served modern mankind. The various peoples of the world were often ranked according to the number of such slaves they possessed; and always with emphasis upon our own high ranking position. This wealth of mechanical slaves was the conclusive proof of the leadership of the engineer in human progress.

Not often was the voice of the sceptic to be heard. Now and then there were warnings, and references to Frankenstein-like monsters. Karl Capek, the Bohemian dramatist, in his melodramatic fantasy, "R U R," of the early twenties, presented a day of reckoning. Few paid any serious attention to the analysis of the problems of science and society as those given by Ayers in his "Science, the False Messiah," or by Coit in his "Is Civilization a Disease." We were complacently satisfied with the achievements of our engineering developments and the controls over the machine, the molecule, and the microbe.

A fortnight ago, when these solemn reflections were being put in order, I had not seen the program for the 1946 meeting of the Society. Neither have I heard any part of the program. It is easy to assume that in the numerous papers and addresses there have been frequent references to the present unhappy state of the world; to the world-wide desolation, hunger and human suffering; to the atomic bomb threatening catastrophe for men everywhere.

It is altogether clear that many men of many minds are in the shadow of the fear that we are approaching a day of wrath; that we are in great danger of moral enslavement by our own material slaves. Moreover, engineers themselves are seemingly realizing that the prime movers of modern life are no longer the engines of engineering, but the mechanisms of politics.

VIII

Throughout the past two or three decades one has been able to observe a creeping uneasiness in the engineering profession. The center of this uneasiness was the realization that, in the working constitution of the engineer, there must be included a political ethic as well as a power technology. Two sets of corrective reactions may be spotted. One, the effort to find a place for humanizing—sometimes called the liberalizing—elements in the training of engineers. The other, the promotion of the participation of engineers in those affairs termed civic. Thus far, there appears to be but little satisfaction, within the profession, as to the results.

As to the application of any dynamic liberalizing of the education of the engineer, will I be forgiven if I say that this chiefly has taken the form of a lip service to the crumbling idols of literary education of another generation? The President of this Society, in his annual address yesterday, sounded a warning to those who believed that "an extension of engineering education by the addition of standard courses

from the departments of liberal arts will make significant contributions to the engineer's preparation for sustaining our social, cultural, and political institutions, or for exercising significant leadership in them."

In all probability, your patience and your sympathy will be put to an acid test by the suggestion *that the engineer, of social as well as scientific qualification, stands in greater need of knowing and of understanding the aspirations of the millions of Little Folk of the present, than of claiming a nodding acquaintance with the inspirations of the hundred Great Books of the past.*

This means that his training will include, as an essential, a range of knowledge and a disposition for action in that field which may appropriately be named *Thermo-Humanics.* That is, the scientific and humane study of those fields of force in which are produced the temperatures that divide and disintegrate men. Who will deny the destructive effects of the struggles going on throughout the world today, centered in the rewards for productive labor, in the possession of raw materials by nations, in differing religious faiths, in race antagonisms, and in that most damaging and insidious form of untruth called Rumor? Do not these, rather than traditional and bookish economics, history, literature, make up the core of any vital liberal education of the engineer qualified for service to that human freedom called democracy? Do not these suggest five new liberal arts?

In the light of the events of the day, one is tempted to add a sixth *R* to these five *R*'s—Russia.

IX

The concept of *Thermo-Humanics* includes acting as well as knowing. A mere observer on the side lines of engineering will observe the evidences of an awakening social conscience on the part of certain leaders in engineering. A good example of this is to be found in the address, "Science Knocks at the Door of American Politics," delivered a year ago by the well known engineer, Morris L. Cooke, at the Conference on the Arts, Sciences, and Professions in the Postwar World. Those of you who have read this address will recall his central arguments—the aloofness, if not the exclusion of scientists and engineers from those critical affairs subject to civic and political decision. There is need for scientists and engineers, to use his own phrase "to woo and win the politicians." "It will be futile," he adds, "to knock at the door of American politics unless we come equipped with both understanding and sympathy". Throughout, he laments the isolation of the men of his profession from active participation in the business of making democracy work.

To be sure there has always been an awareness on the part of engineers of civic-moral elements of their work. In his recent article appearing in the *Journal of the American Society of Civil Engineers,* Professor Ralph B. Wiley, discussing the Engineers' Opportunity to Serve Society, urges engineers to "develop a passionate desire for the good and a hatred of evil." The engineers must "develop a passionate desire for the good and a hatred of evil," and exert their influence "toward the moral and ethical progress with which physical progress should go hand in hand."

"The engineer" the article continues "is under an obligation to inform himself on the political, economic and social trends of the times and to take his part in the solution of our common

problems. In a democracy, where the majority control, isolated individual influence is of little value. It is only by co-operation that good works are accomplished."

"Engineers properly organized can and should make their influence felt in all matters of public policy where technical abilities are needed in these difficult days."

Had I not been too busy to attend to my business, perhaps, I might have completed a study begun several years ago on the place of engineers in the industrial leadership of the country. The partial evidence assembled pointed clearly to the conclusion that trained and experienced engineers are not generally to be found in the positions of controlling leadership of our great industrial, transportation, and communication organizations. An explanation of this may be suggested by the comment with which Morris L. Cooke begins his paper to be given at the International Engineering Congress in Paris next September. He has written, "In normal times, and in accordance with usual custom, *the engineer is engaged on assigned tasks.*" Is it possible that this "hired hand" status, indicated by this statement, represents the real obstacle to the civic participation and contribution of the individual engineer? Certainly a subject worthy of the attention of the Engineering College Research Council.

X

In the collection of my Trivia which were carried to the land of Oblivia are other questions. Perhaps these, rather than the multiple and controverted issue concealed in the term *Thermo-Humanics,* should have been preferred. Under the pressure of the speeding seconds and minutes, I shall flash on the screen of the evening little more than the bare title of two of these questions.

When projecting the needs and service of engineering for the future, is it possible that we have too many schools of engineering for the training of too many men of mediocre aptitudes, abilities, and aspirations, and too few of such schools intensively devoted to the selection and the superior training of men of superior power and promise? Would not an extraordinary opportunity be created for engineers to participate usefully in the operation of the all important mechanisms of government by the formulation of a plan for an engineering job-analysis and time study of the work of members of Congress and the high ranking officers of government? There are many who have the firm conviction that, by such job-analysis and time study, it would be shown that we have yet to adopt practices that permit the best use of the ability of those who have been chosen to accomplish the difficult goals of a democracy. More argument on this and related questions will be furnished on application!

XI

Fifteen years ago there came to my attention a fantastic volume written by an Englishman. It was a work of fiction in which was described with dramatic effects the evolution of the human race during the millennia of the future. Recently I was tempted to reread this book, recalling as I did its uncanny predictions of the world now produced by the release of atomic energy, and the phenomenon of what was called in the book "the Americanization of the planet." *

* "Last and First Men"—W. O. Stapledon (London, 1931).

Will you indulge the reading of two or three significant paragraphs?

"The Dominance of Science: Science now held a position of unique honour among the First Men. This was not so much because it was in this field that the race long ago during its high noon had thought most rigorously, nor because it was through science that men had gained some insight into the nature of the physical world, but rather because the application of scientific principles had revolutionized their material circumstances. The once fluid doctrines of science had by now begun to crystallize into a fixed and intricate dogma; but inventive scientific intelligence still exercised itself brilliantly in improving the technique of industry, and thus completely dominated the imagination of a race in which the pure intellectual curiosity had waned. The scientist was regarded as an embodiment, not merely of knowledge, but of power; and no legends of the potency of science seemed too fantastic to be believed."

"Science itself, the actual corpus of natural knowledge, had by now become so complex that only a tiny fraction of it could be mastered by one brain. Thus students of one branch of science knew practically nothing of the work of others in kindred branches. Especially was this the case with the huge science called Subatomic Physics. Within this were contained a dozen studies, any one of which was as complex as the whole of the physics of the Nineteenth Christian Century. This growing complexity had rendered students in one field ever more reluctant to criticize, or even to try to understand, the principles of other fields. Each petty department, jealous of its own preserves, was meticulously respectful of the preserves of others. In an earlier period the sciences had been coordinated and criticized philosophically by their own leaders and by the technical philosophers. But, philosophy, as a rigorous technical discipline, no longer existed. There was, of course, a vague framework of ideas, or assumptions, based on science, and common to all men, a popular pseudo-science, constructed by the journalists from striking phrases current among scientists. But actual scientific workers prided themselves on the rejection of this ramshackle structure, even while they themselves were unwittingly assuming it. And each insisted that his own special subject must inevitably remain unintelligible even to most of his brother scientists."

"The Culture of the First World State: Such was the physical achievement of this civilization. Nothing half so artificial and intricate and prosperous had ever before existed. An earlier age, indeed, had held before itself some such ideal as this; but its nationalistic mania prevented it from attaining the necessary economic unity. This latter-day civilization, however, had wholly outgrown nationalism, and had spent many centuries of peace in consolidating itself. But to what end? The terrors of destitution and ill-health having been abolished, man's spirit was freed from a crippling burden, and might have dared great adventures. But unfortunately his intellegence had by now seriously declined. And so this age, far more than the notorious 'nineteenth century,' was the great age of barren complacency.

"Every individual was a well-fed and physically healthy human animal. He was also economically independent. His working day was never more than six hours, often only four. He enjoyed a fair share of the products of industry;

and in his long holidays he was free to wander in his own aeroplane all over the planet. With good luck he might find himself rich, even for those days, at forty; and if fortune had not favoured him, he might yet expect affluence before he was eighty, when he could still look forward to a century of active life.

"But in spite of this material prosperity he was a slave. His work and his leisure consisted of feverish activity, punctuated by moments of listless idleness which he regarded as both sinful and unpleasant. Unless he was one of the furiously successful minority, he was apt to be haunted by moments of brooding, too formless to be called meditation, and of yearning, too blind to be called desire. For he and all his contemporaries were ruled by certain ideas which prevented them from living a fully human life.

"Of these ideas one was the ideal of progress."

XII

The great master of the art of jibing the human race, George Bernard Shaw, has somewhere written, "Never pay attention to what old men say. They do not care what happens to the world."

Mr. Toastmaster, I am here tonight because I do care what happens to the world. I do care that my work in the years of the past and your work in the years to come may not be fruitless. You may be listening to one who is superannuated, one outside of your profession and absorbed in his own petty affairs, yet one who does claim to see your business as a critical part of the world's supremely important business.

It has been, I well know, sheer imposition upon your hospitality to pose these questions without profuse answers. It may be that you know the answers. If so, then engineering may be optimistic, and we shall not need to fret; as long as we retain both sides of our heads.

Something I owe to the soil that grew
More to the life that fed
But most to Allah
Who gave me two sides of my head.
I would go without salt and tobacco,
Shoes, shirt and bread
Than for a single instant
Lose either side of my head.

—Kipling

Extract from the Annual Report of the E.C.P.D. Committee on Professional Recognition for 1945

N. W. Dougherty, Chairman,
George F. Bateman, Ole Singstad,
H. T. Heald, George A. Stetson,
Webster N. Jones, A. R. Stevenson, Jr.,
J. A. Vance.

Attributes of a Profession and its Practitioners

Of a Profession:

1. It must satisfy an indispensable and beneficial social need.
2. Its work must require the exercise of discretion and judgment and not be subject to standardization.
3. It is a type of activity conducted upon a high intellectual plane.
   (*a*) Its knowledge and skills are not common possessions of the general public; they are the results of tested research and experience and are acquired through a special discipline of education and practice.
   (*b*) Engineering requires a body of distinctive knowledge (science) and art (skill).
4. It must have group consciousness for the promotion of technical knowledge and professional ideals and for rendering social services.
5. It should have legal status and must require well-formulated standards of admission.

Professional Practitioners:

1. They must have a service motive, sharing their advances in knowledge, guarding their professional integrity and ideals, and tendering gratuitous public service in addition to that engaged by clients.
2. They must recognize their obligations to society and to other practitioners by living up to established and accepted codes of conduct.
3. They must assume relations of confidence and accept individual responsibility.
4. They should be members of professional groups and they should carry their part of the responsibility of advancing professional knowledge, ideals, and practice.

Necrology

ALEXANDER RUSSELL STEVENSON, JR., was born in Schenectady on May 28, 1893, son of Rev. A. R. Stevenson and Mary Margaret Kennedy Stevenson. He attended the Brown School, Schenectady High School and graduated from Princeton University as a Civil Engineer in 1914. He did post-graduate work in electrical engineering at Union College, and received a Master's degree from that college in 1915 and a Ph.D. degree in 1917. At the time of his death he was practicing largely mechanical engineering. In 1917 he entered the Research Laboratory of the G.E. Co., where he worked for a short time on submarine detectors before going into the Air Forces. He was the first officer in charge of testing at Langley Field, and in the fall of 1917 he went to France on the staff of General Foulouis as officer in charge of the radio and electrical section of the Air Forces. He learned to fly at a French flying school at Tours and was later officer in charge of flying and testing at the Experimental Field of the U. S. Air Service in France. He came back to the General Electric Company in 1919, going into the Power and Mining Department where he specialized in the application of synchronous motors and generators.

In 1923 he was transferred to the staff of F. C. Pratt, vice president in Charge of Engineering, where he assisted Robert E. Doherty in establishing the Advanced Course in Engineering and made the preliminary studies which led the Company into the House-hold Refrigerator Field. He later helped to found the Air Conditioning Department and was on various committees of the Appliance and Merchandise Department which brought out the unit kitchen, Disposall, etc.

He was a member of the American Society for Engineering Education, serving as Chairman of the Committee on Relations with Industry last year; he was a member of the Civilian Advisory Council of the Military Training Division, Army Ordnance Department; the first Jet-Propulsion Subcommittee of the National Advisory Committee for Aeronautics, a past president of the American Society of Refrigerating Engineers, a Fellow of the American Institute of Electrical Engineers, and a member of the Engineers' Council for Professional Development. At the time of his death he was vice president of Region III of the American Society of Mechanical Engineers. As assistant to the vice president in charge of engineering policy, Dr. Stevenson had charge of all the engineering education for the Company as a whole.

Dr. Stevenson was a member of Phi Kappa, Sigma Xi, and Pi Tau Sigma honorary fraternities and received an Honorary Doctor of Engineering Degree from Stevens Institute in February of this year.

ROBERT L. SACKETT—To comment adequately upon the life, the achievement, and the interests of a man like Robert L. Sackett is an impossible task.

Few men have been given the wealth and variety of interests which Dr. Sackett possessed, and the privilege is given to few of us to make contributions—very eminently constructive contributions—in so many fields and over such a wide range of human endeavor sustained over such a long period of time.

His first work, characterized as it was by a blending of engineering practice in a consulting capacity and teaching, led him from Earlam College to the Deanship at Pennsylvania State. During this time he was active not only in the educational field, but in the professional field as well, keeping his interest sustained in the fields of both civil and mechanical engineering. He was President of the Society for the Promotion of Engineering Education and received the Lamme Medal of that Society as the foremost teacher of engineering in the then current year, and of this medal and citation he was most proud. Honors were bestowed upon him by his Alma Mater and fortunately in the fields of both education and engineering recognition was accorded to his work. He was a member of many learned societies and contributed substantially throughout the years to technical literature, particularly bearing upon the problems and orientation of the young engineer.

In many ways Dean Sackett's contribution since he left the active teaching profession has been on a broader front than ever. As time progressed, he remained active, serving on boards, committees, and commissions, not only of the engineering societies, but of the Engineers' Council for Professional Development, where he rendered unique services to the profession over many years. He was a marvel of energy to those who knew him best and who appreciated the tremendous range and weight of his responsibilities. I cannot recall having met a man in any field of human endeavor who was so genuinely, so actively, and so consistently constructive in so many varied fields, and I can recall no one who has through the years kept a finer sensitivity to those things which are worthwhile in our lives, and who could take a stand at the same time so firm and so flexible with respect to things of both the mind and the spirit.

It is, however, significant that the things by which Dr. Sackett has been best known, and the thing which will persist longest, is his interest and his thought with respect to the guidance of youth—particularly the young engineer. It is hard to pick out the projects with which he was especially familiar or with which he had uncommon interest for the simple reason that he was familiar with anything—one might almost say everything—which bore upon the relationship of the young man to his profession of engineering, and he was concerned intimately with all movements which served to make that relationship either more stable or more understandable.

His professional work as a consulting engineer in the first years of his professional life was characterized not only by his native good judgment, but by a very definite interest in those things which had to do with the human, the broader and the ethical values inherent in the relations of a consulting engineer with his clients.

In his professional teaching life—particularly in his Deanship at the Pennsylvania State College—this point of view developed, and he found in that situation a chance to practice and test many of his theories and points of view which afterwards became so helpful

over such a wide field. And his help was not limited solely to the students in his own institution. For many young engineers, and I think we can truthfully say for *all* young engineers who came into contact with Dean Sackett, he was always a leader, always inspiring, and furnished, both by precept and example, a pattern which could be followed by the most eminent as well as the most humble.

It has been my privilege to work with him closely, even intimately, in the last dozen years, and to help him as I might with projects which had to do primarily with the choosing and the guiding of young engineers, and I have come to know and to appreciate what a unique and truly remarkable man he was. I have never seen fused into one personality so many of the attributes which are commonly thought to enter into and characterize a great man. Particularly in the later years, when Dr. Sackett was doing some of his best work—a work which he followed through to the end with the same thought and interest and the same vigor which characterized the earlier years—one always found him kindly and firm, *very firm* indeed, in his fundamental concepts concerning matters of morals and ethics. His was a firmness which was born of a deep sincerity of purpose, and with this firmness was a great tolerance, a great resiliency of thought, which made it possible for those of us who were somewhat younger to feel that in him we had always a contemporary—always one who stood at the same age level—although of greater stature, and I would submit that the feeling was shared by young and old alike.

Dr. Sackett never outgrew a fresh and ever renewing interest in the problems of youth, and in many ways he remained youthful in his thinking to the end. No man in the history of American professional education has had more influence on the lives of young men in his own profession than has Dean Sackett. Those of us who are left and who have lost a leader realize only too well how hard his place will be to fill, and while we do realize and feel very deeply a personal loss, greater and more vital even than this will be the loss to many of the younger men in the profession, those just coming in and those who will enter and who will not have the opportunity to profit as we have profited for so long by the activities and interests of a man who considered their interests and their enlightenment a matter of his first concern.

I have marvelled at the wealth and variety of his recreation. I have marvelled as I talked to him about things of professional interest and then watched him paint a picture. I have marvelled, too, at his youth evidenced in his thinking, and his youth evidenced in his recreation of sailing. Neither in his professional life nor in recreation did he have the slightest trace of fear. The startling thing to some of us in this day and this age is that he never complained. I think I never once heard him express a thought that even verged on the cynical.

It seemed to me that in the later years of his life when I came to know him so well, his philosophy was best expressed in the words of another great sailor (for sailing was the sport he loved so well), another hero, in the full sense of the word, for Dean Sackett was truly heroic in mold—a quotation which we shared and enjoyed together:

"There lies the port: the vessel puffs her sail:
There gloom the dark broad seas. My mariners,

Souls that have toil'd, and wrought, and thought with me—
That ever with a frolic welcome took
The thunder and the sunshine . . .
Some work of noble note, may yet be done,
Not unbecoming men that strove with Gods.
The lights begin to twinkle from the rocks:
The long day wanes: the slow moon climbs: the deep
Moans round with many voices. Come, my friends,
'Tis not too late to seek a newer world.
Push off, and sitting well in order smite
The sounding furrows; for my purpose holds
To sail beyond the sunset, and the baths
Of all the western stars, until I die."

The Lamme Medal

The Lamme Medal for achievement in engineering education was established in 1928 by a provision in the will of Benjamin G. Lamme, long Chief Engineer of the Westinghouse Electric and Manufacturing Company. This stipulated that the income from the sum left to the Society for the Promotion of Engineering Education for the purpose should "be expended for a suitable gold medal (together with a bronze replica thereof) to be given yearly to a chosen technical teacher for accomplishment in technical teaching or actual advancement in the art of technical training."

For selection of the medalist, the Society has set up a committee of twelve of its members, three of whom are named by the President each year to serve for four years. The bases for the award employed by the committee for a number of years may be summarized as follows:

(1) Achievements which may be regarded as proof of excellence in teaching or as lasting contributions to the art of technical training are given major consideration.

(2) Contributions to the methods of engineering education through books, articles, or research receive substantial weight in the selection.

(3) Participation in the work of engineering and educational societies which has led to definite and recognized results in bettering technical education is given due consideration but is not necessary for eligibility.

(4) Achievements outside of the field of teaching, as in industry, consulting work, invention, etc., are regarded as of secondary importance.

(5) Administrators in engineering schools are eligible, but are considered only for work which has led to definite improvements in teaching methods or the art of technical training.

(6) Emeritus professors are eligible.

(7) Posthumous awards are not made.

In following these guiding principles, the committee has sought to place primary emphasis upon outstanding achievement as a teacher. In perhaps half of the selections, however, excellence in teaching has been strongly supplemented or surpassed by unusual contributions to the methods and content of engineering education. The bases for the award have been broad but it is believed they have served to make up a roll of Lamme medalists who were already widely recognized as leaders in engineering education but whose work and influence also will long stand the test of time.

Members of the Society are earnestly requested to submit nominations for the award, including with them appraisals of the individual's achievement in the fields listed above, and significant factual information not readily available in Who's Who in America or Who's Who in Engineering. Nominations are requested also directly from members of the committee early in January of each year and the list of candidates for its consideration is made up before February first. Any nominations should be sent to the Committee Chairman, Donald S. Bridgman, American Telephone and Telegraph Company, 195 Broadway, New York.

The George Westinghouse Award

The George Westinghouse Award in Engineering Education was established and the first award made in 1946, the Centennial Anniversary of the birth of George Westinghouse. It consists of a cash award of $1,000 together with an engraved certificate. The presentation is made at the annual dinner of the Society. The money is made possible by the Westinghouse Educational Foundation. The recipient is selected by the American Society for Engineering Education through a nine-man committee appointed by the President of the Society.

The purpose of the award is to recognize and encourage outstanding achievement in the teaching of students of engineering. Candidates may be teachers of any division of subject matter ordinarily taken by engineering students, including, besides the recognized divisions and subjects of engineering, such subjects as English, mathematics, physics and chemistry.

While there are no specific age limitations in making the award, consideration will be given especially to *younger* persons who show by their past record evidence of continuing activity as superior teachers and who are carrying on projects for the improvement of teaching. To them the award may serve not only as a reward but as an incentive toward further work which the funds might make possible.

In order to receive the award a person must have made a clearly discernible contribution to the art and science of teaching. We shall have established achievement in several of the following ways:

(*a*) Success as a teacher must be established both as to competence in subject matter and ability to inspire students to high achievement as demonstrated by the careers of former students.

(*b*) Improvement of the tools of, and conditions for, teaching. Evidence of such achievement may consist of subject matter (textbooks, etc.); courses or curricula; teaching, testing, and guidance techniques; laboratory or other teaching equipment; and other similar activities.

(*c*) Improvement of teaching through various activities, including the development of teachers in a department, contributions to the better preparation of teachers, promotion of co-operation with other types of educational institutions, or with industry, and the co-ordination of fields of subject matter.

(*d*) Improvement of teaching through the effect of personal inspiration and leadership.

The Committee on Award recognizes that the early recognition of an outstanding teacher presents many difficulties. It is the Committee's hope that through continuing study of the problem effective criteria for judging good teaching may evolve.

Nominations may be made by any person, organization or group. They will be received until February 1, 1947. Nominations must be made on

forms available from the chairman of the Committee on Award, Homer L. Dodge, Norwich University, Northfield, Vermont, or from F. L. Bishop, Secretary of the Society, University of Pittsburgh, Pittsburgh 13, Pa. Nominations are filed with the chairman and must be accompanied by documentary evidence supporting all statements and claims.

Agricultural Engineering Teachers Hold Seminar

An Agricultural Engineering Teaching Seminar was held at Purdue University, Aug. 30 to Sept. 4, as one step toward meeting the postwar challenge to agricultural engineering education. The Seminar drew 150 teachers from 42 states and 6 provinces of Canada, including all of the college agricultural engineering departments offering professional training, and others in which teaching is devoted entirely to service or vocational courses. The Ferguson Foundation of Detroit sponsored the seminar, and it was administered by the American Society of Agricultural Engineers, with the cooperation of Purdue University.

Featured program subjects each presented by two or more speakers included "Good Teaching," "The Job to Be Done," "Teacher Improvement," "Course Outlines and Subject Matter," "New Fields for Teaching," and "Techniques and Aids for More Effective Teaching."

Viewpoints of engineering educators from outside the field of agricultural engineering were presented by Dr. A. A. Potter, dean of the school of engineering, Purdue University, in an address on "Aims and Objectives of Higher Education," and by L. M. K. Boelter, chairman of the department of engineering, University of California at Los Angeles, in a contribution to the symposium on "Good Teaching."

Other individual contributions to the program covered subjects ranging from the outlook and objectives of agricultural engineering teaching to measurement of results.

Interest shown in the program and in common problems facing the departments in the new school year indicated that a record number of agricultural engineering students will be given every opportunity and encouragement possible, considering the general shortage of teachers, space, and laboratory facilities.

New Members

BAILEY, ALBERT D., Assistant Professor of Electrical Engineering, University of Illinois, Urbana, Ill. C. E. Keener, L. B. Archer.

BAILEY, WILLIAM A., College Relations Rep., Western Electric Co., Inc., 2500 Broening Hwy., Baltimore 24, Md. W. B. Kouwenhoven, J. T. Thompson.

BERG, LLOYD, Professor and Head, Dept. Chemical Engineering, Montana State College, Bozeman, Mont. S. A. Miller, R. N. Shreve.

BOYD, JAMES, Dean, Colorado School of Mines, Golden, Colo. J. R. Morgan, W. M. Richtmann.

BYRNES, JOHN F., Professor of Industrial Management, Boston College, Boston, Mass. F. L. Bishop, Nell McKenry.

CHRISTIANSEN, JERALD E., Dean, School of Engineering, Industries and Trades, Utah State Agricultural College, Logan, Utah. H. R. Kepner, G. D. Clyde.

CHURCHILL, EVERETT A., Vice President, Northeastern University, Boston, Mass. W. C. White, W. T. Alexander.

CORNELISON, EDWARD D., Chairman, School of Engineering and Technology, Pasadena Junior College, Pasadena, Calif. A. G. Gehrig, Franklin Thomas.

EASTON, ELMER C., Assistant Dean of Engineering, Harvard University, Cambridge, Mass. C. L. Dawes, N. N. Nicholson.

GILLAN, GERALD K., Assistant Professor of Civil Engineering, University of Missouri, Columbia, Mo. Re-admission.

JANKE, ROBERT A., Instructor in Physics, Michigan College of M. & T., Houghton, Mich. M. A. Longacre, T. C. Sermon.

JOHNSON, WALTER L., Assistant Professor, Pasadena Junior College, Pasadena, Calif. A. G. Gehrig, Franklin Thomas.

JOHNSON, WILFRID E., Manager of Engineering, Air Conditioning Dept., General Electric Co., Livingston, N. J. M. M. Boring, K. B. McEachron.

MCNOWN, JOHN S., Assistant Professor of Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa. J. W. Howe, C. J. Posey.

METZGER, A. BURTON, Chief, Personnel Service Dept., Western Electric Co., Inc., Baltimore, Md. W. B. Kouwvenhoven, J. T. Thompson.

MOELLER, ARTHUR C., Instructor in Mathematics, Marquette University, Milwaukee, Wis. L. F. H. Douglas, W. D. Bliss.

RICHMOND, ALLEN P., Assistant to the Secretary, American Society of Civil Engineers, New York City. Re-admission.

SEEGER, EDWIN W., Vice President in charge of Development, Cutler-Hammer, Inc., 315 N. 12th St., Milwaukee, Wis. F. T. Agthe, W. D. Bliss.

SMITH, LINUS B., Professor and Chairman, Dept. of Architecture, University of Nebraska, Lincoln, Nebr. Re-admission.

SPIELMAN, JOHN P., Professor of Metallurgy, Montana School of Mines, Butte, Mont. F. A. Thomson, A. E. Adami.

VOGEL, HERBERT D., Col. U. S. Army, District Engineer, 960 Ellicott Sq. Bldg., Buffalo, N. Y. C. E. Bardsley, F. T. Mavis.

YOUNG, EDWIN H., Instructor in Chemical Engineering, University of Detroit, Detroit, Mich. C. G. Duncomb, W. Gudebski.

60 new members this year

College Notes

Polytechnic Institute of Brooklyn. Ernst L. Midgette has returned to the Polytechnic Institute of Brooklyn, as head of the Department of Mechanical Engineering, from industry where he was director of Research and Design for the American Engineering Company in Philadelphia. Mr. Midgette succeeds Professor Edwin F. Church, Jr., who has been in charge of the department for more than thirty years. Professor Church will continue his affiliation with the Institute.

T-Square Page

Yes—a most stimulating Summer School for Drawing Teachers is rapidly becoming a dim memory. However, just to bring you up to date, the recommendations made by the Summer School Committees were unanimously accepted. These were recorded by our capable secretary, J. Lawrence Hill, as follows:

"1. That the 1946 Summer School recommend to the Drawing Division of the American Society for Engineering Education that a committee be appointed to study the matter of minimum standards for basic courses in engineering drawing, including course content and time allotment, this committee to report at the next annual meeting of the Drawing Division.

"2. That the Division ascertain whether more suitable visual aids in the form of slides or strip films concerning shop processes and their specific relation to dimensioning in the drafting room, are or could be made. It is suggested that industries such as General Motors, through its institute, or the Society for Visual Education or others might be asked if they have these aids. In the event none is available, it is suggested that some educational foundation be approached, through the Council of A.S.E.E., to see if such aids could be developed. Most present shop process films are of the "How to run a lathe" type and are not well adapted to the specific needs of the engineering drawing teacher. A commercial development of the ideas presented by Professor McGuire is recommended.

"3. That the problem of granting drawing credit for previous drafting experience be referred to an appropriate committee for preparation of unit examinations covering all subjects treated in basic drawing courses. These units could then be combined to meet the needs for any particular course of a college or university.

"4. That a committee be appointed to study the projectional material presently on the market and to establish a list of these offerings together with a suggested list for future production.

"That a committee be appointed to offer technical advice to those companies desiring to produce projectional materials and offer reviewing service after the material is completed.

"5. That a committee be appointed to compile information concerning new methods of graphics and specific examples of war projects on which graphics proved of unusual value.

"That a committee be appointed to survey the field of advanced graphics with the purpose of suggesting subject matter for courses and material and textbooks now available for study in this field."

Unprecedented enrollments and the problems of drafting room space, teaching personnel, equipment, etc., has kept most of us very busy during the past few months. Quite likely, these problems will be aggrevated by the influx of new students in the spring semester. Every effort must be made to maintain high standards of work in the field of graphics. *The returning G. I. demands the best of teaching.* He should get it. The present supply of well trained and experienced teachers does not even approach a small percentage of the number needed.

During the next few years it will be necessary to provide "training on the job." The more experienced members of the staff should constitute a faculty to train the young engineer. Teaching schedules should be so arranged that the younger members of the staff could attend lectures given by the most capable professors. In addition, seminars on teaching techniques would be quite appropriate. Weekly seminars would be desirable during the first semester experience of the new appointee.

If you want lively and interesting material for the T-square page—don't be bashful about sending Ye Editor news, items of special interest, your pet peeve, or a professional article on graphics. I need your help! I know you are busy—but who isn't? Drop me a line.

A. S. LEVENS,
Editor

American Society for Engineering Education

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